

What Drives the Economic Activity in the Oil-Producing Countries? An Empirical Evidence for Caspian Countries

George – Eduard GRIGORE*

Bucharest University of Economic Studies, Bucharest, Romania

**Corresponding author, grigoregeorge15@yahoo.com*

Radu – Cristian MUȘETESCU

Bucharest University of Economic Studies, Bucharest, Romania

radu.musetescu@rei.ase.ro

Simona NICOLAE

University Politehnica of Bucharest, Bucharest, Romania

nsim2005@yahoo.com

Oana VLĂDUȚ

University Politehnica of Bucharest, Bucharest, Romania

oanavladut2016@gmail.com

Abstract. *This study investigates and assesses the economic activity in the five Caspian states - Azerbaijan, Iran, Kazakhstan, Russia, and Turkmenistan over the period from 1998 to 2021. In this regard, we used GDP as the dependent variable, while oil production, global oil price, natural gas production, global natural gas price, exports, and inflation were the explanatory variables in order to investigate and capture their impact on the economic activity in these energy-producing countries. In terms of methodology, we performed the regression models often used in the panel analysis - Common Effects Model and Fixed Effects Model, and also applied various robustness and diagnostic tests, namely: F-test, Jarque-Bera test, Breusch-Pagan LM Test or Chow Test. Our results showed that the Fixed Effects Model provides a more accurate estimation of the economic activity (in terms of GDP), since the exports and the oil production have a direct, positive and statistically significant influence on these economies. For instance, a 10% increase in the exports and oil production generates an increase in the level of GDP of about 0.96% and 3.12%. At the same time, the results showed moderate positive and direct correlations between GDP and inflation, as well as between oil prices and inflation, suggesting that oil prices exert a greater influence on producer prices because of oil's role as a key input in these oil-exporting countries. Furthermore, by applying the Vector Error Correction model (VECM), our results showed that the variables are not cointegrated and the level of GDP per capita is not influenced by the co-movements of the explanatory variables in the long-run. In this sense, a policy implication of the study would be to develop more intensive co-operation and build new energy trade relationships between the Caspian Countries and other energy-dependent countries, especially the European Countries.*

Keywords: energy resources, economic activity, Caspian Countries, oil and gas production, inflation, oil price, natural gas price.

Introduction

Developments over the past two years (2020-2022) have led to an acceleration of research in the economic, social, political, healthcare and business fields. From this perspective, the research topics are more and more diverse, interdisciplinary and connected up to the new "global

challenges”, such as: the energy situation, security issues, the forthcoming effects of inflation on the financial system, the implications of the COVID-19 pandemic, and so on (Bergmann, 2019; Yildirim and Arifli, 2021; Amin et al., 2020).

The aim of our study is to investigate the impact of the global oil and natural gas prices on the economic activity in the five Caspian Countries (Azerbaijan, Iran, Kazakhstan, Russia, and Turkmenistan) during the period from 1998 to 2021.

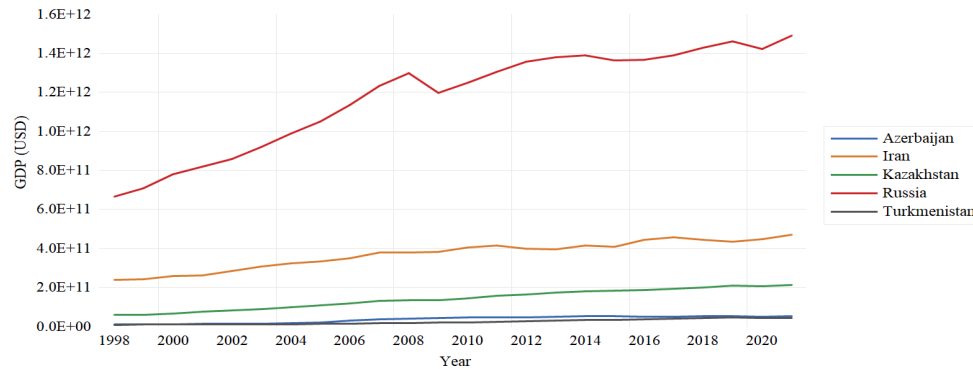


Figure 1. The evolution of the GDP in the Caspian Countries from 1998 to 2021

Source: Authors' own research.

In Figure 1, we can see the dynamic evolution of GDP within the five Caspian countries during the period from 1998 to 2021. Thus, we can notice that the main wealth of the Caspian region is a combination of energy and economic resources - particularly, oil and gas. Energy and economic resources are not only economic goods, but also key elements of state power.

In this way, the variables used are GDP (dependent variable), gas production, global gas price, oil production, global oil price, exports and inflation as the independent variables. From a methodological point of view, we perform the panel analysis by using the two regression models: Common Effects Model (CE) and Fixed Effects Model (FE), as well as applying several robustness and diagnostic tests.

The main objective of our research is to provide an empirical evidence of how economic activity (as measured by the level of GDP) in the Caspian region is impacted/influenced in essence by the behaviour of the explanatory variables, in particular the production of fossil fuels (in our case, natural gas and crude oil), the volatile movements of global prices or the dynamics of these energy resource exports.

Secondly, it is important to see if this interdependence relationship is maintained in the long-term; therefore, we will perform the panel cointegration tests and we will also check the statistical significance of the error correction term (where ECM directly estimate the speed at which a dependent variable returns to equilibrium after a change in other variables) following the application of the vector error correction model (VAR/VECM).

In the third place, we suggest that the measurement/estimation of the economic activity in these five oil-producing countries can stimulate the interest of policy makers (i.e. the European Union) to establish, develop and expand their energy trade relations in order to achieve the objectives of energy efficiency (Damette and Seghir, 2013; Taghizadeh Hesary et al., 2013). Moreover, we also included the inflation rate in the applied methodology in order to observe its effects on the economic activity (economic performance) in the Caspian region.

The structure of our study is as follows: The next section discusses and synthesises the most significant findings from the literature; Section 3 presents the research methodology; and Section

4 highlights our key results and compares them with other empirical evidence. The final section concludes and discusses the implications of our findings from the proposed analysis.

Literature review

The main objective of our study is to estimate and measure economic activity using panel analysis within the five Caspian Countries (Azerbaijan, Iran, Kazakhstan, Russia, and Turkmenistan) over the period 1998-2021. Thus, in this part of the paper, we will present and analyse the main studies that provide sufficient and relevant information for estimating economic activity, as well as identifying the interdependence relationships that can be established between GDP and the rest of the explanatory/independent variables included in the regression models.

From this perspective, in order to estimate the economic trend in net energy producing and exporting countries (in particular, natural gas and oil), most researchers consistently use as a dependent variable the GDP associated/frequently correlated with the global oil price, the global gas price, and the volume of production and exports of these fossil fuels.

In an innovative way, Behrang et al. (2011) proposed the econometric technique known as Gravitational Search Algorithm for the purpose of predicting domestic oil consumption in Iran over the period between 2006 and 2030. Using three econometric models that incorporated explanatory variables of socio-economic conditions (GDP, Population, Import, Export, Light-duty vehicles, Heavy-duty vehicles) on oil consumption in Iran, this study represents a benchmark in the field of energy system modelling. The results also provide useful insights for future energy research and for political decision-makers.

We mention the study conducted by Bolganbayev et al. (2021) which uses panel analysis to explain the causal relationship between global oil prices and economic growth in the Caspian region. The analysis was carried out over the period 2007-2020, and the results obtained indicate the presence of a long-term causal relationship between the two variables, as well as the persistence of the global oil price shocks that continue to significantly disrupt the economic performance in this region. Also, Bolganbayev et al. (2021) illustrated the increasing impact of the global oil price on net exporting countries which continues to increasingly affect economic growth.

Many researchers have been concerned about the possible effects of oil price shocks after the first oil crisis broke out in 1973, so they have turned to examining how specific global oil price shocks generate negative effects on overall economic activity (Hamilton, 1983; Cunado and Perez de Gracia, 2005). For example, fluctuations in global oil prices contribute to lower economic growth in oil-importing countries, an issue captured by Jiménez-Rodríguez and Sánchez (2005).

Understanding that fluctuations in the global price of oil can affect and have serious implications for oil exporting countries, Broni-Berdiako et al. (2018) adopted least square method, an econometric technique which correlates the changes in one variable (dependent variable) to one or more variables (explanatory variables) to measure the impact/effect of the global oil price on the economic activity in Nigeria over the period 1990-2015. The main results accentuate the contribution of oil as the major foreign revenue earner for Nigeria. Based on the results of this study, it is concluded that oil price volatility is linearly related to the macroeconomic variables investigated, and that price volatility has an effect on interest rate, balance of payment, gross domestic product and foreign direct investment on Nigeria's economy.

Given that oil price is becoming more and more volatile, Korhonen and Juurikkala (2007) assessed the causal relationship between global oil price and real exchange rates in a panel analysis of OPEC and three Commonwealth of Independent States (CIS) countries over the period 1975-2005. The authors used econometric cointegration methods, showing the direct and significant

effect of the global oil price on the balance of exchange rates within oil-producing countries. Moreover, the same authors stated that when the oil price increases by 10%, exchange rates appreciate by approximately 5%.

Similarly, other researchers (Chen and Rogoff, 2003; Cashin et al., 2004; Koranchelian, 2005; Zalduendo, 2006; Habib et al., 2017; Lee and Yue, 2017) have demonstrated the significant impact of oil price and productivity against the exchange rates for oil exporting countries. Berument et al. (2010) examine how global oil price shocks can affect economic growth in energy exporting countries. In this context, the variables used were GDP, CPI, Ratio of Oil Exports to Crude Oil Production, Ratio of Net Oil Imports to the GDP, global oil price, inflation, as well as the real exchange rate for the Middle East and North Africa (MENA) countries. The results from the structural vector autoregressive model suggested that as global oil price increases, the shocks in the oil production are linked to a lower impact on the economic activity.

Therefore, the study conducted by Taghizadeh Hesary et al. (2013) also shows the impact of global oil price shocks is differently perceived in oil-producing countries than in non-oil-importing countries. More specifically, they analysed the oil trade relations between the major oil producers (Iran and Russia) and their oil partners (i.e. France, Japan, Italy, The Netherlands, Germany, Turkey, UK, China, and India). The main findings showed that these two producers are both benefiting from the global oil price shocks, which is generating an economic growth of 0.8% for Iran and 7% for Russia. But the picture is different for oil-importing countries; the results show that they are experiencing a decrease in their GDP due to the global oil price shocks.

In addition, we mention the study conducted by Fazaeli et al. (2016) in which the main purpose is to validate the existence of a long-run causality relationship between GDP and the level of healthcare expenditure on the OPEC oil exporting countries over the period from 1995 to 2012. By using specific econometric techniques for panel analysis (panel unit root tests, cointegration test, Vector Error Correction Model), the results affirmed the existence of a long-run relationship between the two variables and the fact that the public healthcare expenditures/spending are often higher in the OPEC countries compared to other developed countries. Moreover, the statistically significant value of the long-run elasticity coefficient for GDP (0.89) indicated that health is a strict necessity in the analysed oil exporting countries.

At the same time, Nyangarika et al. (2018) also identified the presence of a high and statistically significant causality relationship between the global oil price and the GDP in the case of oil producing countries. The proposed econometric analysis was conducted over the period between 1991 and 2016 and was based on the FIGARCH autoregressive model. Another contribution of this study showed the negative impact of global oil prices on economic growth in both Russia and Saudi Arabia, which would require a transition to renewable or alternative energy in the near future.

Bergmann (2019) has similarly proposed a variety of parametric and non-parametric VAR models to capture the causal relationships between GDP and global oil price shocks at the level of the 12 countries studied. The results indicated that the oil price increases have a lower effect on GDP growth the lower the oil-to-energy ratio. Another finding of the study is that oil-importing countries clearly profit from a decreasing oil-to-energy share whereas oil-exporting countries show a more variable behaviour. Furthermore, the response of GDP growth is significantly weakened along with lower oil shares.

Applying the Johansen cointegration test, Gokmenoglu et al. (2015) demonstrated the existence of the long-run relationship between the global oil price, inflation, GDP and the level of industrial production in Turkey during 1961-2012. The findings of the study performed by Mehrara

(2007) at the level of the 11 net oil producing and exporting countries during the period 1971-2002 captured the unidirectional Granger relationship between energy consumption per capita and GDP per capita. In a similar approach, Boheman and Maxén (2015) examined how economic growth in the 11 OPEC and 8 non-OPEC countries is susceptible to any global oil price shock. Using VAR methodology, they were able to observe the impulse-response functions, the results indicating that a 1% increase in oil price generates a GDP growth rate in the next year of approx. 0.145% for OPEC countries and 0.141% for non-OPEC countries.

A comparable approach in order to explore the economic performance was taken by Lee (2005). Employing a vector error correction model, cointegration panel analysis (full-modified OLS), it was shown the long-run relationship between energy consumption and GDP level within the 18 developing countries over the period 1975-2001.

Additionally, Mahadevan and Asafu-Adjay (2007); Damette and Seghir (2013) investigate the cause-effect relationship between energy consumption and economic growth at the level of the most important producers of petroleum products in different time periods from 1971-2002 and from 1990-2010. Using FMOLS, DOLS approach, error correction model, as well as performing panel cointegration tests, the two authors found that there exists a long-run equilibrium relationship between energy consumption and economic growth.

Furthermore, the empirical evidence of a dynamic panel error-correction model reveals a short-run unidirectional causality from energy consumption to economic growth, whereas in the long-run, it is the economic process that determines the energy consumption trend. Finally, the authors concluded that energy endowment in these countries is an extremely important pillar of economic activity measurement, which will facilitate the adoption of energy policies to conserve/conserves oil reserves in the near future, as well as to make energy systems more efficient or sustainable.

In the other perspective, there are studies that investigate economic growth by taking into account the export, the import, the inflation and the trade openness. In this regard, we mention the study conducted by Adu-Gyamfi et al. (2020), where based on the Pooled OLS Model, Fixed Effects Model, and Random Effects Model, the direct effects of trade openness and inflation on the economic activity of 9 West African countries were determined.

The main findings highlighted the negative impact of inflation as well as trade openness on economic growth in these countries. Similarly, other studies (Drukker et al., 2005; Mamo, 2012) have used panel methodology to analyse the interaction between inflation and economic growth. The results categorically showed the non-linear and negative effect of inflation to economic growth as well as the bi-directional Granger relationship in both variables.

Autoregressive distributed (ARDL) models were also used by Sek et al. (2015) to capture the interdependence relationship between changes in global oil price, inflation, GDP and real exchange rate for 20 countries grouped according to their dependence on oil products in the interval between 1980 to 2010. The results of the study confirmed the existence of a long-term causal relationship between the variables as well as the evidence that oil price change has its direct effect on domestic inflation in the low oil dependency group but its impact is indirect on determining the domestic inflation in high oil dependency group.

Cunado and Perez de Gracia (2005) did not detect the presence of a long-run relationship between global oil prices, economic growth and inflation at the level of the six Asian countries during the period from 1975 to 2002. The authors also find a short-run interdependent relationship between oil prices and economic growth rates; oil price shocks are found to drive economic growth rates in Japan, South Korea and Thailand via the Granger effect.

Amin et al. (2020) used panel methodology at the level of 7 Southeast Asian countries in order to analyse the long-term relationship between education, employment, income, inflation, energy poverty and economic development. Examining the time period from 1995 to 2017, it was noted that education and employment contribute positively to long-term economic development, generating an increase of 6.41% respectively 484.62%. At the same time, the results showed that the lack of energy resources and the inflation rate lead to a decrease of 29.81% of the economic development in this region, in both the long and short term.

More recently, the research conducted by Yildirim and Arifli (2021) proposes a VAR methodology in order to investigate the direct and indirect effects of the global oil price on the economic growth in Azerbaijan. Using monthly data for the global oil price, real exchange rate, trade balance, inflation rate and GDP over the period 2006-2018, the findings of this study indicated the Azerbaijan economy is adversely influenced by an oil price decline, and a negative oil price shock deteriorates trade balance, causes a depreciation of home currency, increases inflation and falls economic activity.

A new approach to study the causality nexus between energy consumption and economic growth is presented in the study carried out by Rodriguez-Caballero (2022). The proposed methodology is based on a type-II fractionally integrated panel data model and Monte Carlo simulations to capture multiple co-movements between blocks of stationary and non-stationary variables.

For this purpose, the author has constructed a panel composed of 69 countries grouped into four geographical regions, which has enabled a better analysis of the elasticity of energy consumption with respect to economic growth, as well as considering that the estimates in some empirical studies may have some positive biases caused by neglecting the presence non-pervasive cross-sectional dependence and long- range dependence processes.

Using GDP per capita as the dependent variable, electricity consumption per capita and gross capital formation as explanatory variables, the results suggested a lower level of elasticity between the variables, as well as the detection of a unidirectional long run causality relationship between energy consumption per capita and GDP per capita.

Methodology

The aim of our research is to estimate the economic activity in the Caspian countries (Azerbaijan, Iran, Kazakhstan, Russia, and Turkmenistan) in the period from 1998 to 2021.

For this purpose, we used GDP as a dependent variable and several key variables (independent/explanatory variables), the data for all the variables have an annual frequency and they are collected from various sources. They are presented in table 1.

Table 1. The description of explanatory variables

Variable	Acronym	Definition	Measurement unit	Data source	Type of variable in model
Gross Domestic Product	GDP	GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products.	Constant 2015 USD	World Bank	Dependent variable

Variable	Acronym	Definition	Measurement unit	Data source	Type of variable in model
Natural gas price	NG _{PRICE}	Henry Hub Natural Gas Spot Price	USD per Million Btu	U.S. Energy Information Administration	Independent variable
Oil price	O _{PRICE}	Europe Brent Spot Price FOB	USD per Barrel	U.S. Energy Information Administration	Independent variable
Natural gas production	NG _{PRODUCTION}	The annual amount of natural gas production or reserves by country	TWh	Our World in Data ¹	Independent variable
Oil production	O _{PRODUCTION}	The annual quantity of oil reserves by country	TWh	Our World in Data ²	Independent variable
Exports	EXP	Exports of goods and services represent the value of all goods and other market services provided to the rest of the world.	Current USD	World Bank	Independent variable
Inflation	INFL	Inflation is a rise in prices, which can be translated as the decline of purchasing power over time.	%	Statista ³	Independent variable

Source: Authors' own research

The variables have been selected according to the contributions in existing academic literature and to their main findings (Cunado and Perez de Gracia, 2005; Drukker et al., 2005; Adu-Gyamfi et al., 2020; Boheman and Maxén, 2015). Since most studies have investigated the interdependence between GDP and fluctuating global oil price movements for the net oil exporting and oil producing countries (Amin et al., 2020; Berument et al., 2010; Bergmann, 2019; Jimmez-Rodriguez and Sanchez, 2005; Se et al., 2015), in our analysis we proposed to incorporate the global price of natural gas as an independent variable.

Figure 2 shows the evolution of the global price of natural gas and crude oil, showing a downward trend in the period from 2019 to 2021, which has been maintained until now. We also follow the research direction found in studies by Yildirim and Arifli (2021); Sarmah and Bal (2021); Mamo (2012); Gokmenoglu et al. (2015) and we use two other explanatory variables in measuring economic activity in the Caspian Countries, namely oil production and natural gas production.

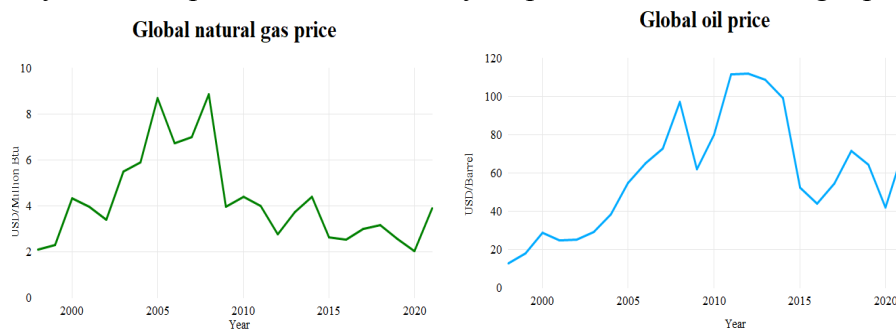


Figure 2. The evolution of the global natural gas and oil prices from 1998 to 2021

Source: Authors' own research.

¹ <https://ourworldindata.org/grapher/gas-production-by-country>

² <https://ourworldindata.org/grapher/oil-production-by-country>

³ <https://www.statista.com/>

Figures 3 and 4 show notable differences in oil and gas production for each country under analysis, Russia taking the leading position at over 6000 TWh of annual oil production and approximately 7000 TWh of annual gas production. These data certify that, albeit the Soviet influence is still high in this region and there are several security concerns, the rich reserves of fossil fuels constitute a principal driver for the expansion of commercial relations with other energy importing countries (i.e. European Countries) in the near future.

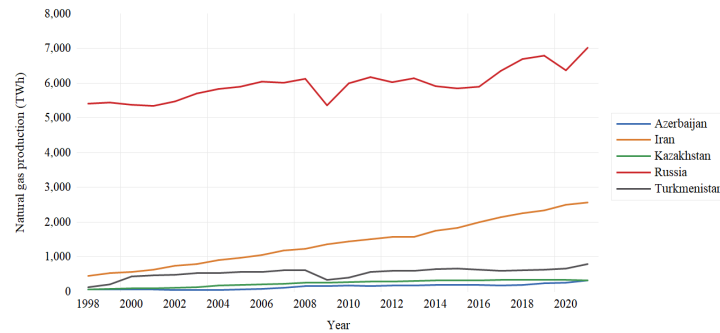


Figure 3. The evolution of the natural gas production in the Caspian Countries from 1998 to 2021

Source: Authors' own research.

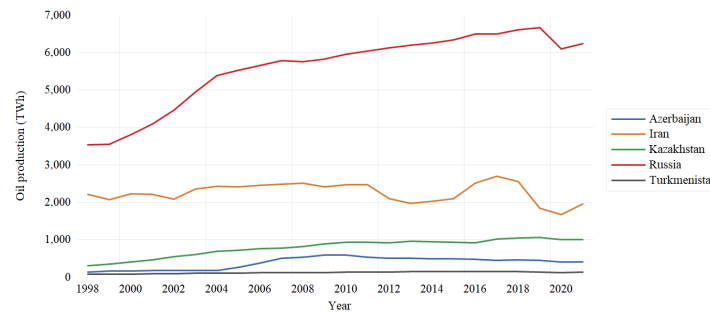


Figure 4. The evolution of the oil production in the Caspian Countries from 1998-2021

Source: Authors' own research.

On the other hand, we believe that it is important for the economy of any country to be financially and monetarily stable, which is why the econometric model takes into account the inflation rate (the evolution is shown in Figure 5). In addition, we would like to examine the interdependence between inflation and the rest of the variables we have used.

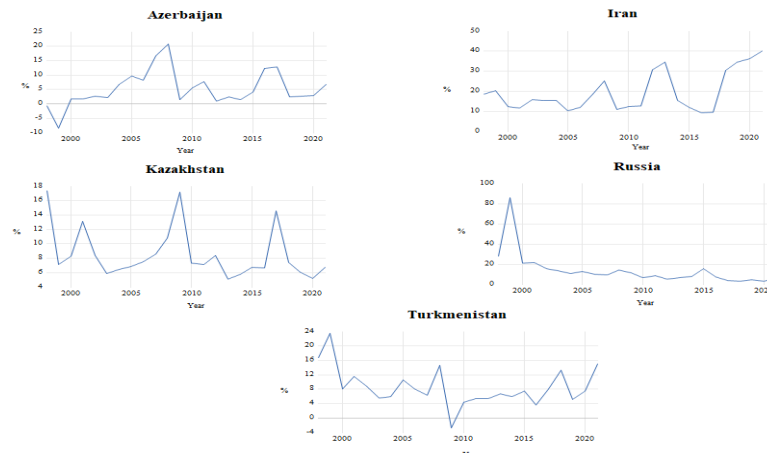


Figure 5. The evolution of the inflation rate in the Caspian Countries from 1998 to 2021

Source: Authors' own research.

In order to obtain consistent results, each variable is expressed in a logarithmic and differenced form, except for the inflation rate that is presented as a percentage ratio. The research methodology used in this study is represented by the regression models: Common Effects Model (POLS) and Fixed Effects Model (FE) with panel data. The form of the econometric model is represented below:

$GDP_{it} = \beta_0 + \beta_1 NG_{PRODUCTIONit} + \beta_2 NG_{PRICEit} + \beta_3 O_{PRODUCTIONit} + \beta_4 O_{PRICEit} + \beta_5 EXP_{it} + \beta_6 INFL_{it} + \alpha_i + \varepsilon_{it}$ (1), where i represent the country ($i = 1$ to 5); t indicates the time ($t = 1998$ to 2021); β_0 is the constant term; $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6$ are the coefficients for each independent/explanatory variable; α_i represents the country-specific error component and this varies between countries, and ε_{it} indicates the error term which captures the impact of unobserved variables that vary both across countries and over a period of time.

We emphasise that these econometric models are some of the most popular and widely used methodologies for investigation in the field of economics and finance due to their ability to capture time series interdependencies and autocorrelation. Data Panel Regression is a combination of cross section data and time series, where the same unit cross section is measured at different times. So in other words, panel data is data from some of the same individuals observed in a certain period of time.

Thus, panel regressions provide a better estimation and prediction, because it has a double index on its variables; the index i which shows the cross-sectional dimension and the index t indicates the temporal dimension. For this reason, using the panel methodology approach, we can measure the impact of a single coefficient on specified independent variables across time and entities and, also we are able to determine and estimate these regressors (Zulfikar, 2018; Baltagi, 2008; Schmidheiny, 2013). Another advantage derives from the fact that panel methodology can estimate the coefficients in a dynamic and modified way, in which can be controlled by the individual fixed effects.

According to Zulfikar (2018) and Codirlaşu et al. (2010), a panel data model approach (Common Effects Model or POLS Model) is the easiest because it only combines time series and cross-section data. In this model, time and individual dimensions are not taken into consideration, so it is assumed that the behaviour of corporate data is the same in various periods. This method can use the Ordinary Least Square (OLS) approach or the least squares technique to estimate the panel data model.

On the other hand, the Fixed Effects Model (FE) can serve as a viable alternative to the Common Effects Model (CE or POLS Model). This model tests the presence of individual effects and the component (α_1) can be correlated with the regressors (X_{it}), however it still maintains the hypothesis that there is no correlation between X_{it} and the random error component (ε_{it}). This Model allows for heteronomy or individually for all countries by allowing it to have its own intercept value. The assumption of using Fixed Effects Model is that this produces a constant intercept for each cross section and time is considered less realistic, so more models are needed to capture the difference. This estimation model is often also called the technique of Least Squares Dummy Variable (LSDV).

The next methodological steps that we have undertaken were to verify and test the presence of unit roots in the panel series (in this regard, stationarity was tested by Levin-Lin-Chu, ADF, Im, Pesaran tests); to perform correlations between variables and their statistical testing, to estimate coefficients after applying the regression models, as well as to perform several robustness and diagnostic tests (F-test, Jarque-Bera test, Breusch LM test). Furthermore, we assess on which regression model is appropriate/suitable for estimating GDP by applying the Chow Test.

Finally, we implemented the vector autoregressive model (VAR/VECM) in several steps: we used the logarithmic form of the variables, we tested for the stationarity, we determined the optimal lag length (for our data we applied lag 2), we estimated the elasticity coefficients, as well as we checked the long-run relationship between GDP and the rest of the explanatory/endogenous variables in our panel (Lee, 2005; Mehrara, 2007; Mehadevan and Asfu-Adiaye, 2007; Dammette and Seghir, 2013).

The total number of observations is 120, resulting from 5 Caspian Countries (cross-sectional dimension) and 24 years (temporal dimension) for each country in the panel and the econometric analysis was carried out using EViews 12 (Student Version).

Results and discussions

In this section, the main results of the econometric analysis are presented and discussed. Our first step was to describe the statistics of the variables, calculating the mean, median, Skewness and Kurtosis indicators as well as the standard deviation.

Descriptive statistics of all variables used in our research are presented in Table 2. Thus, most of the variables have a flattened distribution (platykurtic distribution), meanwhile the oil price is closer to the normal distribution form (mesokurtic distribution), and the inflation deviates most from the normal distribution, having a leptokurtic form.

Simultaneously, diversity in the variables is also observed in the Skewness indicator: the inflation has a positive skewness (data distribution occurs more on the one side of the scale with a long tail on the right side) and the oil price, oil production, GDP have a negative skewness (the tail of the distribution is longer on the left side, and the mean is lower than the median and mode). We also note that the natural gas production and the exports are mainly close to the fairly symmetrical distribution, indicating a normal distribution of data. In terms of the standard deviation, we find that both inflation and exports deviate mostly from the mean by 10.54% and 1.65%. The oil price and the natural gas price deviates the slightest from the mean, between 0.40% and 0.60%.

Table 2. The descriptive statistics for explanatory variables

Variable/Indicator	GDP	NGPRODUCTION	NGPRICE	OPRODUCTION	OPRICE	EXP	INFL
Mean	25.58	6.41	1.35	6.71	3.94	24.25	11.08
Median	25.67	6.33	1.36	6.80	4.06	24.33	8.27
Maximum	28.02	8.85	2.18	8.80	4.71	27.11	85.70
Minimum	22.82	3.81	0.70	4.30	2.54	20.46	-8.53
Std. Dev.	1.56	1.48	0.41	1.38	0.58	1.65	10.54
Skewness	-0.01	0.17	0.39	-0.06	-0.63	-0.25	3.50
Kurtosis	1.80	2.04	2.30	1.74	2.59	2.48	23.04
Jarque-Bera	7.11	5.17	5.43	7.98	8.83	2.58	2253.87
Observations	120	120	120	120	120	120	120

Note: The variables are presented in logarithmic form (expected inflation rate)

Source: Authors' own research

On the other hand, the stationarity in the time series data is a precondition for the implementation of Common Effects Model (POLS/CE), Fixed Effects Model (FE) and the vector autoregressive (VAR/VEC) Models, thus it is checked with panel unit root tests. The results of the unit root tests with panel data are presented in Table 3.

The four tests applied (i.e. Levin, Lin and Chu, Im, Pesaran and Shin, ADF-Fisher, and PP-Fisher Tests) indicate that all variables are stationary with an extremely high level of probability (p-value is less than 0.001).

Table 3. The results of unit root tests for explanatory variables

Variable/Unit root test	Levin, Lin and Chu Test	Im, Pesaran and Shin Test	ADF-Fisher Test	PP-Fisher Test	Validation
GDP	-3.24*	-3.76*	32.75*	32.65*	<i>Stationary</i>
NG_{PRODUCTION}	-4.96*	-4.56*	43.18*	62.25*	<i>Stationary</i>
NG_{PRICE}	-9.72*	-9.82*	86.53*	86.96*	<i>Stationary</i>
O_{PRODUCTION}	1.26	-1.44*	19.17*	30.85*	<i>Stationary</i>
O_{PRICE}	-8.87*	-7.66*	66.15*	66.12*	<i>Stationary</i>
EXP	-5.27*	-4.33*	40.57*	51.02*	<i>Stationary</i>
INFL	-5.95*	-4.72*	40.61*	38.89*	<i>Stationary</i>

Note: * indicates statistically significance at 1% level

Source: Authors' own research

From another perspective, we consider that it is useful and helpful to see if between the GDP and the explanatory variables are linked ("correlations") before performing the specific panel analysis regression models. There is therefore a strong positive correlation between GDP and natural gas production; exports and oil production; GDP and oil production; respectively between GDP and exports, which confirms that the economic activity of the Caspian Countries is strongly related to the energy production and oil and natural gas exports

At the same time, the results show the positive and moderate correlation between natural gas production and inflation; GDP and inflation, as well as between exports and inflation, suggesting that the changes in the price of oil products, natural gas and electricity, which are diffused, generate variations in the prices of all products in the domestic market (Al-Shammari and Al-Qenaie, 2017; Amin et al., 2020; Bolganbayev et al., 2021; Cunado and Perez de Gracia, 2005; Gokmenoglu et al., 2015).

The positive GDP-inflation correlation can be explained as follows: increasing prices lead/generate an apparent increase in Gross Domestic Product in current prices, but when we do the deflation, we find that inflation has a negative influence on the real GDP (Mamo, 2012; Sarmah and Bal, 2021; Sek et al., 2015).

The value of 0.49 indicates the existence of a positive and moderate interaction between the global oil price and the exports, which shows that a change in the global oil price affects the dynamic of exports in the net oil producing countries (including the Caspian States) and therefore implies a change in terms of economic growth. The results of these correlations are shown in Table 4.

Table 4. The correlation between the explanatory variables

Variable	GDP	NG_{PRODUCTION}	NG_{PRICE}	O_{PRODUCTION}	O_{PRICE}	EXP	INFL
GDP	1.000						
NG_{PRODUCTION}	0.806*	1.000					
NG_{PRICE}	-0.038	-0.020	1.000				
O_{PRODUCTION}	0.976*	0.735*	0.016	1.000			
O_{PRICE}	0.201**	0.217**	0.3272*	0.157***	1.000		
EXP	0.937*	0.749*	0.056	0.914*	0.489*	1.000	
INFL	0.312*	0.339*	-0.066	0.2904*	-0.1496***	0.183**	1.000

Note: * indicates statistically significance at 1% level; ** indicate statistically significance at 5% level; *** indicate statistically significance at 10% level

Source: Authors' own research

Next, we present the specific results of the two regression models applied: Common Effects Model and Fixed Effects Model in order to detect the dependence relationship between GDP and the rest of the explanatory variables.

The results of the estimated regression coefficients as well as the specific individual cross-sectional effects from the FE model are illustrated in Table 5. Thus, oil production and exports have an impact on economic activity in the five Caspian Countries, since the estimated coefficients are statistically significant at 1% p-value.

More specifically, when oil production increases by 10%, the GDP changes in the same direction, and increases by 3.2% respectively 0.31% according to the regression models used (CE and FE Models). The same is true for exports, e.g. a 10% increase in these exports generates an increase of approximately 1% in the level of GDP of the Caspian Countries.

Our results are similar to other empirical studies (Taghizadeh Hesary et al., 2013; Yildirim and Arifli, 2021; Mehrara, 2007; Nyangarika et al., 2018). Most of these studies investigate the dependence relationship between GDP and global oil prices at the level of energy producing and exporting countries, especially OPEC and OECD countries. However, the results provided by the Fixed Effects Model also captured the individual intercepts, highlighting the cross-sectional deviations from the overall intercept mean.

In contrast to the rest of the studies which have investigated the interdependence relationship between GDP and inflation (Drukker et al., 2005; Zalduendo, 2006; Bergman, 2019), our findings revealed that the inflation does not directly influence GDP, as the estimated coefficients are statistically insignificant (p-value is more than 5%).

Table 5. The results of estimated coefficients according to panel regression models

Panel Specification	β_0	$NG_{PRODUCTION}$	NG_{PRICE}	$O_{PRODUCTION}$	O_{PRICE}	EXP	$INFL$
<i>Common Effects Model</i>	0.0337*	0.0245	-0.0162	0.3235*	-0.0111	0.0950*	-0.00000784
<i>Fixed Effects Model</i>	0.0294*	0.0126	-0.0159	0.3121*	-0.0106	0.0955*	0.000405
The estimated Cross- section Fixed Effects (individual intercept)							
<i>Azerbaijan</i>	0.0128*						
<i>Iran</i>	-0.0124*						
<i>Kazakhstan</i>	-0.0038*						
<i>Russia</i>	-0.0170*						
<i>Turkmenistan</i>	0.0205*						

Note: * indicates statistically significance at 1% level

Source: Authors' own research

Furthermore, the panel data regression models used in the present study are robust and appropriate to estimate the economic activity in the Caspian Countries, the value of the F-test and its probability (p-value is less than 0.05) confirm this aspect. In addition, GDP is highly explained by the explanatory variables used, with 58% in the case of Common Effects Model or 63% according to the Fixed Effects Model. At the same time, the results of the diagnostic tests validated that our model is homoskedastic (variance of the residual, or error term, in a regression model is constant), no serial correlation or autocorrelation is not present in the residuals series, and the errors are normally distributed. These findings are presented in Table 6.

We also investigated which of the two regression models provides the most accurate and realistic estimation of the economic activity across the Caspian Countries. The results showed that the Fixed Effects Model is more appropriate to measure economic activity, a fact confirmed by the statistical significance of the Chow test. In a comparative manner, this test evaluates/compares the Common Effects Panel and Fixed Effects Panel and presents the following hypotheses: H_0 : There are no individual fixed effects; and H_1 : There are individual fixed effects). Additionally, Figure 5 shows the estimate of economic activity (fitted GDP) at the level of the Caspian states according to the selected Fixed Effects Model.

Table 6. The robustness results and diagnostic tests for panel regression models

Panel specification	Adj. R ²	F-statistic	Prob. F-statistic	Normality test (Jarque-Bera)	Breusch-Pagan LM Test
<i>Common Effects Model</i>	0.5765	28.0086	0.0000	0.3580 (0.8360)	9.8799 (0.4511)
<i>Fixed Effects Model</i>	0.6275	21.0497	0.0000	1.7799 (0.4106)	13.3406 (0.2052)
Chow Test	4.8643 (0.0012)				

Note: The probability of these diagnostic tests is indicated in the brackets.

Source: Authors' own research

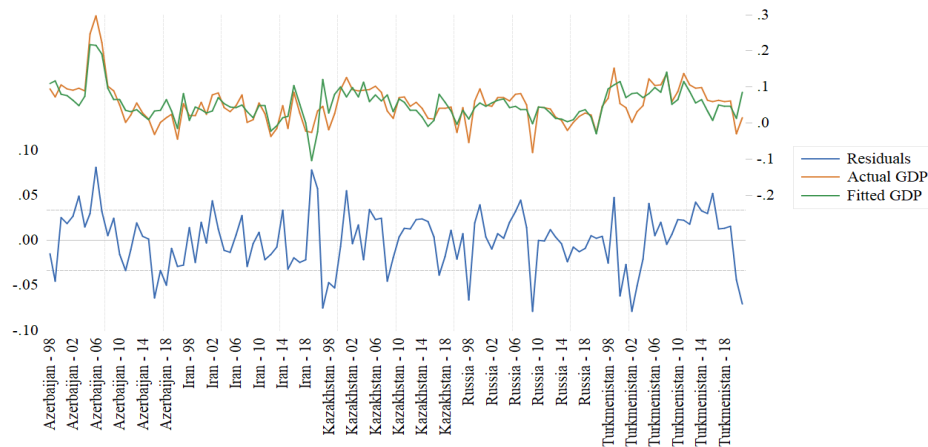


Figure 5. The estimated GDP in the Caspian Countries from 1998-2021 according to the Fixed Effects Model

Source: Authors' own research

In a similar manner to other studies (Amin et al., 2020; Berument et al., 2010; Boheman and Maxen, 2015; Broni-Bediako et al., 2018), we investigated if the interdependence relationship between GDP and the explanatory variables is maintained in the long run. Thus, the first step was to perform Kao and Pedroni cointegration tests. The results in Table 7 show a possible long-term correlation between the variables.

Table 7. The results of the cointegration tests

Pedroni Residual Cointegration Test		
Method	Statistic	Weighted Statistic
Panel v-Statistic	-1.6168 (0.9470)	-1.1755 (0.8801)
Panel rho-Statistic	2.1157 (0.9828)	1.2398 (0.8925)
Panel PP-Statistic	1.5011 (0.9333)	-0.599140 (0.2745)
Panel ADF-Statistic	1.6043 (0.9457)	0.3031 (0.6191)
Group rho-Statistic	1.9408 (0.9739)	
Group PP-Statistic	-0.7264 (0.2338)	
Group ADF-Statistic	-0.2734 (0.3923)	
Kao Residual Cointegration Test		
-1.621343 (0.0525)		

Note: The probability of these diagnostic tests is indicated in the brackets.

Source: Authors' own research

For this purpose, we implemented the Vector Error Correction Model in several steps: we determined the optimal lag length selection criteria (in our case, using annual frequency data and

in order not to lose data/information, we opted for 2 lags), we checked for cointegration using Johansen test and we estimated the short and long term coefficients.

Another aspect was to assess the statistical significance of the long-term coefficient. The -1.1354 value of the statistical test and its associated probability of 0.25 (greater than 0.05) for the error correction term confirmed that there is no long-term relationship between GDP and the underlying variables. That aspect was captured and quantified by the following empirical studies: Jimenez-Rodriguez and Sanchez (2005); Köse and Ünal (2020); Lee (2005) or Mahadevan and Asafu-Adiaye (2007). These findings are summarised in Table 8.

Table 8. The estimated long-run and short-run coefficients according to VECM Analysis

	Coefficient	Std. Error	T-statistic	Probability	Long-run determination
ECT – C(1)	-0.008071	0.007109	-1.135425	0.2589	No

Source: Authors' own research

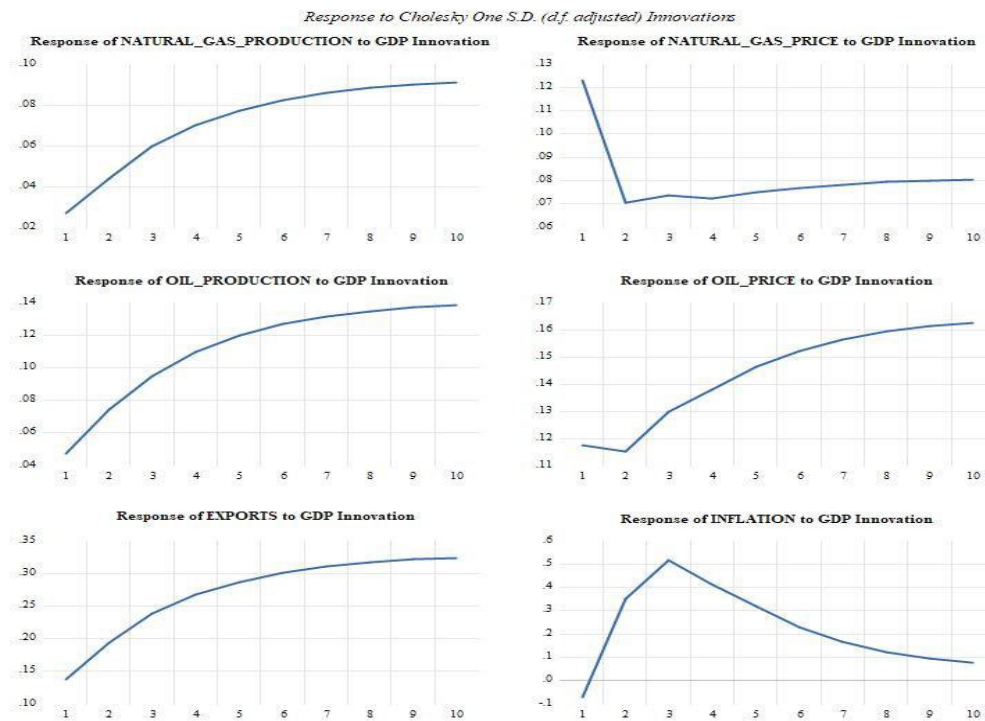


Figure 7. Impulse response functions according to the Vector Error Correction Model

Source: Authors' own research

The impulse response functions (Figure 7) were implemented using Choleski innovations with a standard deviation over a period of 10 years. They showed that a one SD shock (innovation) to GDP will have a positive impact on global oil price, oil production, and exports. For example, a one SD shock to GDP initially increases inflation. This positive response sharply decreases from the 2nd -5th period, and beyond the 6th period, inflation has a decreasing tendency, but still remains in the positive region.

Moreover, the positive response of the global natural gas price to GDP Innovations sharply declines from 1st to 3rd period when it hits its steady state value. For instance, our results are consistent, because oil prices can drive job creation and investment as it becomes economically

viable for oil companies to exploit higher-cost shale oil deposits. In this perspective, the development of the oil and gas production capacities and the increase of their exports should be the main drivers of the competitiveness of the economic activity in the Caspian Countries.

Conclusion

In this paper, the main objective was highlighted by the examination of the interdependence relationship on the economic activity in the Caspian Countries - Azerbaijan, Iran, Kazakhstan, Russia, and Turkmenistan over the period from 1998 to 2021. For this purpose, we used the following variables to test this relationship: the GDP as the dependent variable, the global oil price, the global natural gas price, the natural gas production, the oil production, the export volume and the inflation as the explanatory/independent variables.

At the methodological level, we applied the regression models (specific to panel data), namely Common Effects and Fixed Effects Models; we performed several diagnostic and robustness tests, as well as we employed the vector autoregressive model (VAR/VEC) to determine a possible long-run cointegration relationship between the variables.

The results surprised several aspects: first of all, the economic activity in this region is dependent on the domestic production of oil, so their own economies are susceptible to positive or negative impacts from oil prices. In this context, we are referring also to the ability of the Caspian Countries to develop their export options and to establish and/or to expand their energy trade relations in the near future, even if the Russian influence in this region is still being increased and preserved.

Secondly, intensified production of oil-related products causes a dramatic dependency on the oil price and this generates the following problem: exporting oil-related products creates foreign currency revenue, but this production method does not allow manufacturing industries to develop and gain power in international trade. As a result, a political implication would be that the Caspian Basin Countries should create industrial base production and invest more in manufacturing industries that focus on export rather than in oil-related industries.

In this way, these countries can create a substitution effect against negative oil price shocks. However, it was also found that the inflation and the global oil price have more of a marginal impact on the measurement of the economic activity in these countries. In future studies we intend to strictly investigate their dependency relationship and to assess the long-term causal relationships between them using the Granger analysis, starting from the following hypothesis: the price elasticity of oil demand is relatively inelastic in these economies, which makes it a profitable resource for producer countries.

Furthermore, we notice some limitations of the present research, due to the availability of the data and to the econometric techniques used. Our future research will expand the panel data by including more energy-producing and energy-exporting countries in order to provide a more comprehensive and comparative analysis of the economic activity, as well as more sophisticated methodologies may be employed.

References

- Adu-Gyamfi, G., Nketiah, E., Obuobi, B., & Adjei, M. (2020). Trade Openness, Inflation and GDP Growth: Panel Data Evidence from Nine (9) West Africa Countries. *Open Journal of Business and Management*, 8(1), 314-328. DOI: 10.4236/ojbm.2020.81019
- Al-Shammari, N., & Al-Qenaie, J. (2017). Causes Of Inflation Across Main Oil Exporting Countries (An Empirical Study). *Journal of the Faculty of Commerce for Scientific Research*,

54(2), 93-116. Retrieved from https://www.researchgate.net/publication/333245375_Causes_of_Inflation_Across_Main_Oil_Exporting_Countries_An_Empirical_Study

Amin, A., Liu, Y., Yu, J., Chandio, A. A., Rasool, S. F., Luo, J., & Zaman, S. (2020). How does energy poverty affect economic development? A panel data analysis of South Asian countries. *Environmental Science and Pollution Research*, 27, 31623–31635. DOI: <https://doi.org/10.1007/s11356-020-09173-6>

Baltagi, B. H. (2008). *Econometric Analysis of Panel Data* (ed. Third Edition). John Wiley & Sons, Ltd.

Behrang, M.A., Assareh, E., Ghalambaz, M., Assari, M.R., & Noghrehabadi, A.R. (2011). Forecasting future oil demand in Iran using GSA (Gravitational Search Algorithm). *Energy*, 36 (9), 5649-5654. DOI: <https://doi.org/10.1016/j.energy.2011.07.002>

Bergmann, P. (2019). Oil price shocks and GDP growth: Do energy shares amplify causal effects? *Energy Economics*, 80, 1010-1040. DOI: <https://doi.org/10.1016/j.eneco.2019.01.031>

Berument, M. H., Ceylan, N. B., & Dogan, N. (2010). The Impact of Oil Price Shocks on the Economic Growth of Selected MENA Countries. *The Energy Journal*, 31(1), 149-176. Retrieved from <https://www.jstor.org/stable/41323274>

Boheman, H., & Maxén, J. (2015). Oil Price Shocks Effect on Economic Growth – OPEC versus non-OPEC Economies. Retrieved from <https://www.lunduniversity.lu.se/lup/publication/7374279>

Bolganbayev, A., Myrzabekkyzy, K., Baimaganbetov, S., & Kelesbayev, D. (2021). The Effect of Oil Prices on the Economic Growth of Oil Exporting Countries Bordering the Caspian Sea: Panel Data Analysis. *International Journal of Energy Economics and Policy*, 11(6), 432-437. DOI: <https://doi.org/10.32479/ijeep.11835>

Broni-Bediako, E., Onyije, I.J., & Unwene, K.K. (2018). Economic Effects of Oil Price Volatility on Developing Countries: A Case Study of an Oil Exporting Country. *International Journal of Economics & Management Sciences*, 7(2), 1-5. DOI: 10.4172/2162-6359.1000509

Cashin, P., Céspedes, L. F., & Sahay, R. (2004). Commodity currencies and the real exchange rate. *Journal of Development Economics*, 75(1), 239-268. DOI: <https://doi.org/10.1016/j.jdeveco.2003.08.005>

Chen, Y.-c., & Rogoff, K. (2003). Commodity currencies. *Journal of International Economics*, 60(1), 133-160. DOI: [https://doi.org/10.1016/S0022-1996\(02\)00072-7](https://doi.org/10.1016/S0022-1996(02)00072-7)

Codirlaşu, A., Moinescu, B., & Chidesciuc, N. A. (2010). *Econometrie avansată [Advanced econometrics]*. Retrieved from https://www.researchgate.net/publication/326410312_Econometrie_avansata

Cunado, J., & Perez de Gracia, F. (2005). Oil prices, economic activity and inflation: evidence for some Asian countries. *The Quarterly Review of Economics and Finance*, 45(1), 65-83. DOI: <https://doi.org/10.1016/j.qref.2004.02.003>

Damette, O., & Seghir, M. (2013). Energy as a driver of growth in oil exporting countries? *Energy Economics*, 37, 193-199. DOI: <https://doi.org/10.1016/j.eneco.2012.12.011>

Drukker, D., Gomis-Porqueras, P., & Hernandez-Verme, P. (2005). Threshold Effects in the Relationship Between Inflation and Growth: A New Panel-Data Approach. *MPRA Paper*. Retrieved from <https://mpra.ub.uni-muenchen.de/38225/>

Fazaeli, A. A., Ghaderi, H., Salehi, M., & Fazaeli, A. R. (2016). Health Care Expenditure and GDP in Oil Exporting Countries: Evidence From OPEC Data, 1995-2012. *Global Journal of Health Science*, 8(2), 93-98. DOI: 10.5539/gjhs.v8n2p93

Gokmenoglu, K., Azin, V., & Taspinar, N. (2015). The Relationship between Industrial Production, GDP, Inflation and Oil Price: The Case of Turkey. *Procedia Economics and Finance*, 25, 497-503. DOI: [https://doi.org/10.1016/S2212-5671\(15\)00762-5](https://doi.org/10.1016/S2212-5671(15)00762-5)

Habib, M. M., Mileva, E., & Stracca, L. (2017). The real exchange rate and economic growth: Revisiting the case using external instruments. *Journal of International Money and Finance*, 73, Part B, 386-398. DOI: <https://doi.org/10.1016/j.jimonfin.2017.02.014>

Hamilton, J. D. (1983). Oil and the Macroeconomy since World War II. *Journal of Political Economy*, 91 (2), 228-248. <https://www.jstor.org/stable/1832055>

Jiménez-Rodríguez, R., & Sánchez, M. (2005). Oil price shocks and real GDP growth: empirical evidence for some OECD countries. *Applied Economics*, 37(2), 201–228. DOI: <http://dx.doi.org/10.1080/0003684042000281561>

Koranchelian, T. (2005). The Equilibrium Real Exchange Rate in a Commodity Exporting Country: Algeria's Experience. *IMF Working Papers*, No.135/2005, 1-18. Retrieved from <https://www.imf.org/en/Publications/WP/Issues/2016/12/31/The-Equilibrium-Real-Exchange-Rate-in-a-Commodity-Exporting-Country-Algerias-Experience-18318>

Korhonen, I., & Juurikkala, T. (2007). Equilibrium exchange rates in oil-dependent countries. *BOFIT Discussion Papers*, No. 8/2007, 1-21. Retrieved from <https://publications.bof.fi/handle/10024/48190>

Köse, N., & Ünal, E. (2020). The impact of oil price shocks on stock exchanges in Caspian Basin countries. *Energy*, 190, 116383. DOI: <https://doi.org/10.1016/j.energy.2019.116383>

Lee, C.-C. (2005). Energy consumption and GDP in developing countries: A cointegrated panel analysis. *Energy Economics*, 27(3), 415-427. DOI: <https://doi.org/10.1016/j.eneco.2005.03.003>

Lee, J., & Yue, C. (2017). Impacts of the US dollar (USD) exchange rate on economic growth and the environment in the United States. *Energy Economics*, 64, 170-176. DOI: <https://doi.org/10.1016/j.eneco.2017.03.006>

Mahadevan, R., & Asafu-Adjaye, J. (2007). Energy consumption, economic growth and prices: A reassessment using panel VECM for developed and developing countries. *Energy Policy*, 35(4), 2481-2490. DOI: <https://doi.org/10.1016/j.enpol.2006.08.019>

Mamo, F. (2012). Economic Growth and Inflation: A panel data analysis. Retrieved from <http://sh.diva-portal.org/smash/record.jsf?pid=diva2%3A576024&dswid=-8419>

Mehrara, M. (2007). Energy consumption and economic growth: The case of oil exporting countries. *Energy Policy*, 35(5), 2939-2945. DOI: <https://doi.org/10.1016/j.enpol.2006.10.018>

Nyangarika, A. M., Mikhaylov, A. Y., & Tang, B.-j. (2018). Correlation of Oil Prices and Gross Domestic Product in Oil Producing Countries. *International Journal of Energy Economics and Policy*, 8(5), 42-48. Retrieved from <https://www.econjournals.com/index.php/ijeep/article/view/6802>

Rodríguez-Caballero, C. V. (2022). Energy consumption and GDP: a panel data analysis with multi-level cross-sectional dependence. *Econometrics and Statistics*, 23, 128-146. DOI: <https://doi.org/10.1016/j.ecosta.2020.11.002>

Sarmah, A., & Bal, D. P. (2021). Does Crude Oil Price Affect the Inflation Rate and Economic Growth in India? A New Insight Based on Structural VAR Framework. *The Indian Economic Journal*, 69(1), 123-139. DOI: <https://doi.org/10.1177/0019466221998838>

Schmidheiny, K. (2013). *Panel Data: Fixed and Random Effects [Short Guide to Microeconometrics]* Retrieved from <https://www.schmidheiny.name/teaching/panel2up.pdf>

Sek, S. K., Teo, X. Q., & Wong, Y. N. (2015). A Comparative Study on the Effects of Oil Price Changes on Inflation. *Procedia Economics and Finance*, 26, 630-636. DOI: [https://doi.org/10.1016/S2212-5671\(15\)00800-X](https://doi.org/10.1016/S2212-5671(15)00800-X)

Taghizadeh Hesary, F., Yoshino, N., Abdoli, G., & Farzinvash, A. (2013). An Estimation of the Impact of Oil Shocks on Crude Oil Exporting Economies and Their Trade Partners. *Frontiers of Economics in China*, 8(4), 571-591. DOI: <https://doi.org/10.3868/s060-002-013-0029-3>

Yildirim, Z., & Arifli, A. (2021). Oil price shocks, exchange rate and macroeconomic fluctuations in a small oil-exporting economy. *Energy*, 219, 119527. DOI: <https://doi.org/10.1016/j.energy.2020.119527>

Zalduendo, J. (2006). Determinants of Venezuela's Equilibrium Real Exchange Rate. *IMF Working Paper*, No. 074/2006, 1-17. Retrieved from <https://www.imf.org/en/Publications/WP/Issues/2016/12/31/Determinants-of-Venezuelas-Equilibrium-Real-Exchange-Rate-19034>

Zulfikar, R. (2018). Estimation Model and Selection Method of Panel Data Regression: An Overview Of Common Effect, Fixed Effect, And Random Effect Model. Retrieved from <https://doi.org/10.31227/osf.io/9qe2b>