Macroeconomic Implications of Oil prices on Net Oil Importing and Exporting Emerging Economies: The Case of Latin America

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GitHub repo - https://github.com/Yonas-Berhe/WQU_MSFE_Capestone_project

Abstract

Oil is an important commodity that drives economic growth and transforms nations. Emerging economies are especially affected by oil price variabilities since their economies are in a vulnerable state and it is characterized by imperfect markets. This study examined the long-term relationship between the oil prices and economic growth of Colombia and Chile, a net exporter and net importer respectively. Moreover, the research compares and contrasts the implications of oil price shocks on the macroeconomic conditions of the two countries. The results of the investigation disclose the effects of oil price shocks were lower on the macroeconomic indicators of the net exporter nations and show a negative influence on the level of inflation. However, the effect is positive on the macroeconomic variables of the net oil importer nation with higher magnitudes of inflation and interest rates.

Keywords: *Emerging Economies, oil prices, economic growth, VECM, SVR, impulse response, Latin America, Colombia, Chile*

1. Introduction

Oil is by no doubt an important source of economic and political power. Oil prices hit their peak of US$145 In 2008 and US$ -37 per barrel in 2020. These, rapid changes in world oil prices pose a significant influence on the economic activity of nations. Variabilities in oil prices are usually caused by shocks to the demand and supply of oil. World events such as the Arab oil embargo of 1973–1974, the global financial crisis of 2007-2008 as well as the prevailing COVID pandemic which cause severe industrial and financial implications can be mentioned as an example. These events disrupt energy consumption and lead to fluctuations in world oil prices. Furthermore, these fluctuations in oil prices have been found to affect major macroeconomic aspects of world economies.

In emerging economies, oil plays a significant role in economic growth and prosperity by improving the nation's balance of trade and attracting investment opportunities. Consequently, fluctuations in oil prices can also lead to detrimental effects on their economy through high inflation, or fiscal deficits for oil-producing countries when oil prices decrease abruptly. However, the production and consumption of oil between nations is not similar, therefore the impact of price changes on their economies and globally tends to vary greatly. Fig (1), show the stark difference between advanced and developing economies in their relation to changes in oil prices.

Latin American countries are some of the fastest-growing economies in the world, and they happened to be some of the most oil-exporting and importing emerging economies as well. We decided to shift our studies to this region of the world to narrow down our scope of research and get specific results through an empirical and comparative study. Therefore, in this Capstone Project, we explore and examine the implications of changes in oil prices on the macroeconomic conditions of selected countries from Latin America as case studies.

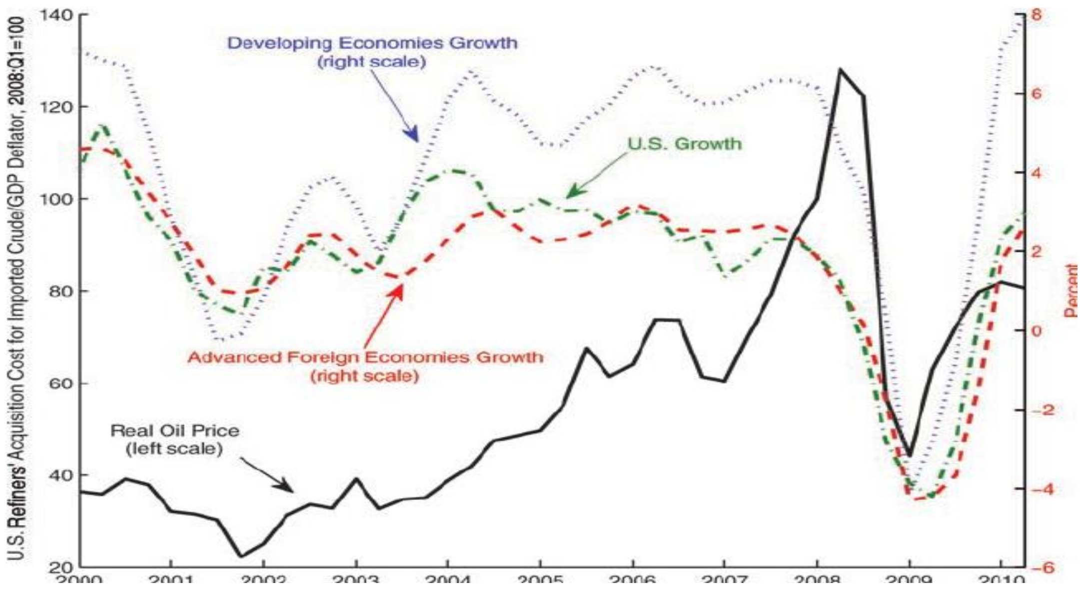

Fig 1. Recent Global GDP Growth and Real Oil Prices
Source: (Erceg et al., 2011) (Did Easy Money in the Dollar Bloc Fuel the Oil Price Run-Up?)

This research study intends to contribute to the limited body of literature discussing the effects of oil prices on emerging economies. This study will complement the existing literature with the examination of oil prices on economic activity by considering a wide variety of macroeconomic factors and exploring the characteristics of the oil markets within each nation. Results obtained from this case study will add valuable information to the previous findings.

The emerging economies under investigation possess a comparable GDP, share similar geopolitical influences and similar socioeconomic circumstances. Some are net oil exporters and net oil importers, with relative economic similarity. Our study has the unique advantage of examining and comparing the effects of oil prices in their emerging economies by considering the oil markets as a source of distinction.

The findings give us an insight into how oil prices impact the emerging economies of net oil exporters and importers. Although other factors contribute to the macroeconomic conditions of these countries, we believe that our selection of the countries based on proximity, similar economic and social aspects offer the comparative edge we chose to explore in this study.

We believe that insights gained from this study will assist investors and policymakers in making data-driven decisions by devising risk management strategies against oil shocks and identifying other diversification opportunities.

2. Literature Review

Several studies have been carried out in this area, however, the majority of the literature suggested that most of the studies were predominantly carried out in advanced economies. (Baumeister & Hamilton, 2019) investigated the effect of oil demand and supply shocks on the U.S. economic output. Studies such as those of (Lippi & Nobili, 2012) stretched it to the influence of oil price fluctuations on the industrial production in the U.S. and (Peersman & Van Robays, 2012) extended even further to other advanced economies. Generally, the results of these studies and other similar studies propose that supply-driven oil prices shocks are associated with declining economic activity but demand driving oil price shocks have the opposite effect of increasing economic activity.

A paper by (Kabundi & Ohnsorge, 2020) examined the implications of supply and demand-driven oil prices on the economic growth of emerging markets and developing economies (EMDE). The authors employed structural vector autoregression (SVAR) to identify the impact of demand and supply shocks. Annual GDP the sample of 153 EMDEs were included in the regression from 1970- 2018, of which 34 EMDEs were oil-exporting countries. The study observed that oil price downfalls resulted in huge GDP losses to the energy-exporting EDMEs, but no significant gains were found in the energy importing countries. Another study by (Rafiq & Salim, 2014) inspected the effects of oil prices fluctuations of six Asian emerging economies using time-series cross-section and time-series econometric techniques. The results reveal that oil prices shocks were damaging to these emerging economies. However, countries with shielding government policies such as Thailand's emergency oil funds played a significant role in alleviating the adverse effects of the oil price volatility on the overall economy.

Other studies employed the vector autoregressive (VAR) approach and several co-integration methods, in order to assess the long-run relationship of oil prices and the level of economic activity. (Alenoghena, 2021) investigated the effects of oil prices on the Nigerian economy using the structural vector autoregression (SVAR) on various macroeconomic variables. The findings indicated that oil price variability considerably and negatively affected economic growth and industrial output. A study by (Jawad & Niazi, 2017) examined the effects of oil prices on the GDP of Pakistan. The results showed that the effects of oil price change were stable to the most extent. In the case of developed countries, a study by (Kurihara, 2015) investigated a relationship between oil prices and the economies of the US, EU, and Japan. The study finds that oil prices increase generally benefit their economies, but the exact relationship of oil price variability on the macroeconomic indicators was unclear.

Besides the main macroeconomic variables, other studies also investigated the impact of oil prices on the local stock market performance of oil exporting and importing countries. (Alqattan & Alhayky, 2016), using mainly the autoregressive distributed lag, studied the impact of changes in oil prices in countries that are part of the Gulf Cooperation Council for the period of November 2006 to February 2015. They found no co-integration between oil prices and the stock market in the 6 GCC countries, except Oman.

(Stavros Degiannakis, 2018) reviewed research on the relationship between oil prices and stock markets, they found that the majority of research papers focused on the impact of oil prices on financial market performance and not the reverse. In this paper, channels through which oil prices affect the economy are talked about such as the stock valuation channel, lower or higher expected cash flow from an investment, or whether a valuation of a listed company increased or decreased. The study concluded that the rapid movement of oil prices creates uncertainty in the economy. (Youssef & Mokni, 2019) investigated the role that the stock market has on the dynamic linkage of the economic relationship of net oil importers and exporters. Using DCC FIGARCH to study the relationship between markets for the period 2000-2018, they noted that the stock market of oil- importing countries was more impacted by changes in oil prices than oil-exporting countries. Depending on the origin of the change in oil prices, changes in the business cycle, or global turmoil, the dynamic relationship of oil and stock was different. (Carlstrom & Fuerst, 2005) note the fact that an increase in oil prices preceded every recession since 1971 and question if the recessions were caused by the oil prices or monetary policy responses. They noted that, without a change of rate by the Federal Reserve just after an oil price shock, the output declines in the economy would have been the same anyway, in other words, systematic action by the Federal Reserve on the interest rates, as a reply to an oil price shocks, were not effective to prevent output declines.

Given our literature review, the effects of oil prices seem to be inconclusive and heavily dependent on the economies under investigation as well as the time period considered under study. In our research project, we plan to analyze the implication of a change of oil prices on the economy of net oil-importing and exporting countries

3. Exploratory Data Analysis

Among the 6 selected countries, we started with the 5 countries with the largest GDP in Latin America plus Venezuela, which produces the most in terms of oil production per capita. Brazil is the biggest oil producer in Latin America with near 3 million barrels produced per day according to the Energy Information Administration (Kempkey & Peterson, n.d.). In terms of production per capita, Colombia and Venezuela are the ones producing more oil than any other country.

	Oil production (bbl/day)	Oil production per capita (bbl/day/million people)	GDP ($million), 2021 IMF estimate	Bbl per day per $millions of GDP
Brazil	2,939,950	12,113	1,491,772	1.97
Mexico	1,710,303	17,142	1,192,480	1.43
Argentina	440,335	11,644	418,150	1.05
Colombia	791,844	18,452	295,610	2.68
Chile	1,582	247	307,938	0.01
Venezuela	527,063	18,821	42,530	12.39

Table 1: Descriptive Statistics

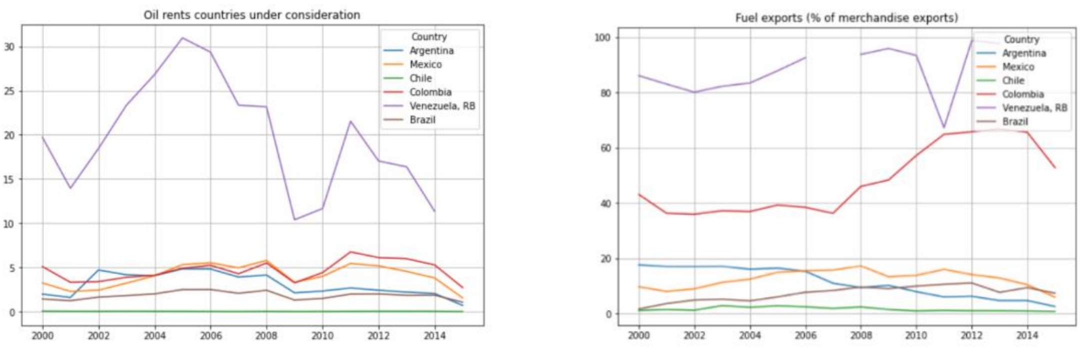

Figure 1: Oil rents and Fuel exports in Latin America
Source: World Bank

In terms of dependency to oil production, Oil revenue for Chile are very low, the country is a net importer. Venezuela's GDP is the most dependent on oil production with 12 barrels per day per USD millions of annual GDP, the following on the list is Colombia with 2.68 barrels per day per USD millions of annual GDP. Venezuela had the highest oil rent as a % of GDP in all the years considered and the country is known to have an economy that is highly dependent on oil-related revenues. We will, however, work with Colombia and Chile for our analysis as Colombia is also a net exporter of oil and publicly available data that can be analyzed.

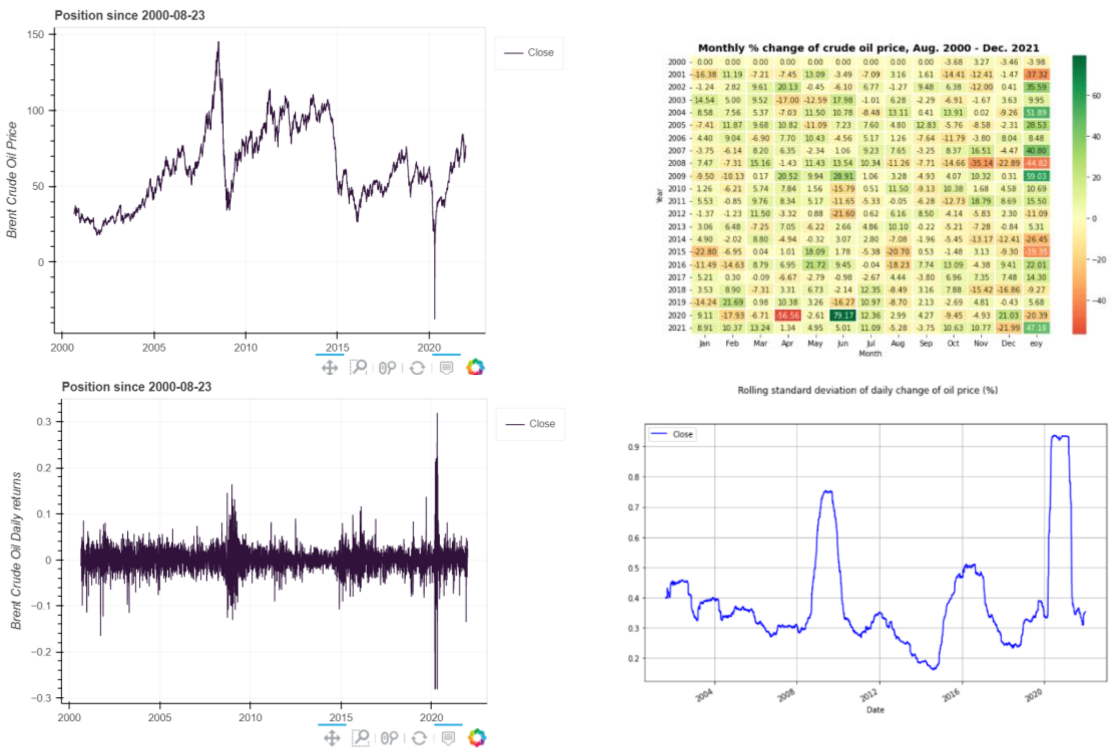

Figure 2: Oil Prices and Volatility
Source: Yahoo Finance and own computation

From 2000 to 2021, oil prices experienced period of high volatility such as in 2008, 2014-16 and 2020 as indicated by the different plots above and especially the rolling standard deviation plot.

In 2008, the financial crisis was ongoing and a decrease in supply caused by different events around the globe pushed the oil price to record high. Among the events we can mention, are strikes in Nigeria of union workers, the legal battle between Exxon and Venezuela that saw the supply of oil from Venezuela disrupted, etc. (Smith, 2009).

In mid-2014, the monthly oil price change was negative for 7 months in a row, the decline of the oil price continued until February 2016. The plunge of oil price was driven by growing supply not followed by demand (Stocker et al., 2018).

In April 2020, the price of a barrel of crude oil declined by more than -50%, the largest decline in a month for Brent Crude Oil since 2000. The Covid 19 pandemic and measures taken to mitigate it, created a disruption in oil demand, and fears that oil consumption would stay at a very low level drove the price of a barrel to a record low.

The selected countries for this study almost have the same GDP, one is a net importer of oil, this is Chile and the other one, Colombia, is a net exporter of oil.

The largest oil producer in Colombia is Ecopetrol, a publicly owned company. The market cap of Ecopetrol is USD 28.7 Billion as of January 2022 and represents around 9% of the GDP of Colombia. The share price of the company is, as expected positively correlated with the oil prices with a 0.61 correlation for the period 2008-2020.

4. Empirical Analysis Long run relationship

4.1 Long run relationship between oil prices and economic activity

In the previous section, we have shown through exploratory analysis the state of oil production in the selected LA nations. we have also explored the condition of oil prices over the years. The analysis allowed us to identify the net oil importers and exporters of oil in that LA region. The main objective of this section is to evaluate the short and long-run relationships as well as causality between world oil prices and economic activity of net importers and exporters of oil in LA countries. The main objective of this section is to analyze the long-term impact of world oil prices on the economic activity of these nations. this will allow us to draw a distinction on the different mechanisms their economies respond to this oil price movement over time.

Based on our analysis we have decided to use the economies of Colombia and Chile as a proxy for net oil exporter and net oil importer respectively. Given their comparative economic capacity, we decided to use the GDP per capita as a proxy as a measure of economic activity prevailing in these nations. We will assess the relationship using 20 yearly data from January 2000 to January 2020. This will be carried out by exploring the existence of common spurious regression as well as understanding the speed, magnitude, and direction of the co-integration of these prices over time. Understanding the linkage between oil prices and economic output is imperative for proper policy implementation in order to reduce the negative impact of oil price fluctuations on the oil-dependent economic systems.

4.2 Data Sources

This research study uses the crude oil benchmark prices of Brent Blend spot prices from yahoo finance as a proxy for the global oil prices. The macro- economic variable for Colombia and Chile considered in the investigation are GDP per capita measured in US dollars as a proxy for measuring a nation's level of economic activity. The data for GDP per capita (GDPPC) was obtained from The World Bank and Federal Reserve Economic Data (FRED) through python API’s.

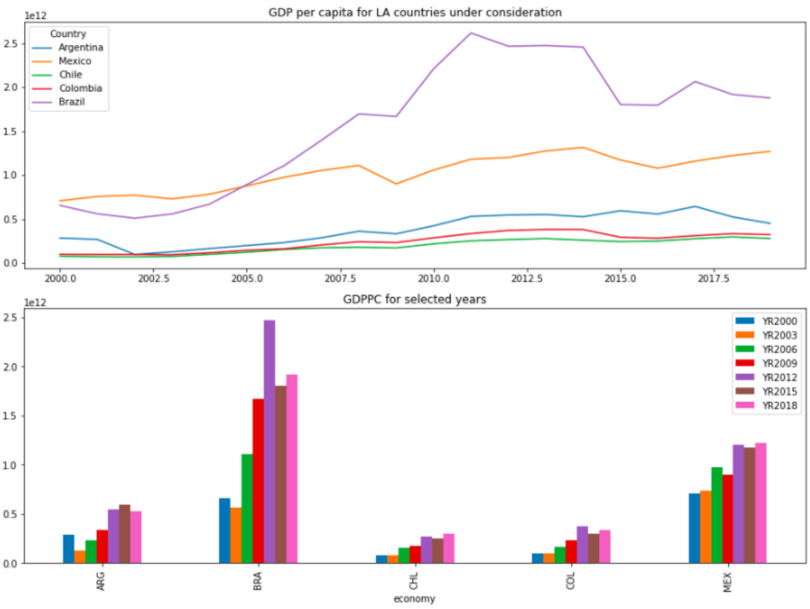

Figure 3: GDP Per Capita for Selected Countries
Source: World Bank

The data series are yearly observations from 2000 to 2020, a total of 20 observations. The period and the frequency of the selected dataset adopted for this study are based on data availability. Fig. 3 shows the time series for the oil price and GDP per capita of both nations.

4.3 Methodology

The vector autoregressive (VAR) model is a multivariate time series model which considers multiple independent time series as endogenous and used the past values or lags of these series in order to estimate and forecast the values dependent variables. VAR models formulate the response of macroeconomic indicators to certain economic shocks and their contribution to economic activity (Fomby et al., 2013). The VAR models is expressed as follows. Where: Oil prices and GDPPC represent log values of oil prices, GDP per capita respectively, C is constant term α and β are the variable coefficient, and μ is the residuals or the white noise.

$$\ln GDPPC_t = C + \alpha_i \sum_{i=1}^{n} \ln Oil_{t-i} + \beta_j \sum_{j=1}^{n} \ln GDPPC_{t-j} + \mu_t$$

According to the Engle–Granger approach (Engle & Granger, 1987) which states that if two variables are cointegrated, then both must be linked by an error correction model (ECM). A VECM imposes additional cointegration restriction information more than the VAR into its information. With the VECM we can interpret the long-term and short-term equations and analyze the dynamics of oil price and economic growth. These error correction models are specified as such:

$$ECM = \ln GDPPC - \beta_0 - \beta_1 \ln Oil$$

$$\delta \ln GDPPC = \gamma_{i,j} + \gamma_{i,j}(\delta \ln Oil)_{t-i} + \gamma_{i,j}(\delta \ln GDPPC)_{t-i} + \alpha ECMt_i + v_t$$

The difference values are represented by the δ operator for Oil prices and GDPPC, where GDPPC is the dependent variable. The α is the error correction term that measures the speed of adjustment at which short-run deviations from the long-run equilibrium are corrected in the next period. The γ measures the short-run elasticity, and the β from the ECM equations now measures the long-run elasticity of transmission.

4.4 Stationarity Analysis

In numerous studies, it has been observed that most economic and prices data series tend to be non-stationary with unit-root at the level I(0) but become stationary after differencing the series (Abimelech et al., 2017). The augmented Dickey-Fuller test (ADF) (Dickey & Fuller, 1981) report on *(See Appendix Table A.1)* for Colombia indicates that the GDPPC is stationary but oil prices are non-stationary at the level I(0) *(See Appendix Table A.3)*. However, after taking the second difference GDPPC and Oil prices became stationary. Similarly, the GDPPC for Chile is stationary at level I(0) but remains non-stationary even after taking the first and second differences *(See Appendix Table A.2)*. Oil prices, on the other hand, were non-stationary at level I(0) and after taking the second difference are transformed into a stationary series.

4.5 OLS and Granger causality

Although the VAR requires that the economic variables have to be stationary We believe we can extract valuable information exploring their long-run relation by running an OLS regression setting GDPPC as a response variable and oil price as a predictor variable.

For Colombia, the oil price seems to explain almost 68% of the variations seen in the GDPPC and the coefficient is positive and significant at a 5% level of significance *(See Appendix Table A.4)*. For Chile, oil prices explain almost 63% of the variation seen in the country's GDPPC and the coefficient is also positive and significant at a 5% level of significance *(See Appendix Table A.5)*.

	GDPPC_x	Oil price_x
GDPPC_y	1.0	0.0227
Oil_price_y	0.0	1.0000

	GDPPC_x	Oil price_x
GDPPC_y	1.0	0.0001
Oil_price_y	0.0	1.0000

Table 2: Granger table for Colombia(above) and Chile(below)

We have also conducted the Granger causality test in order to determine whether oil prices series is useful in forecasting the GDPPC of those nations. the results of the test are expressed usually through a series of t-tests and F-tests on lagged values of oil price and GDPPC to predict future values of GDPPC in the unrestricted VAR (Granger, 1969). Table (2) shows that when oil prices are set as a causing variable and GDPPC as a response variable it indicates that the p-values are lower than 0.05 for both countries. therefore, the estimates for GDP per capita (GDPPC) suggest that global oil prices granger causes GDPPC for both Colombia and Chile at 5% significance level.

4.6 Cointegration

The study conducted a test of cointegration among the global oil price and GDPPC of both countries using the Johansen Cointegration method. The cointegration test examines the spurious and long-run relationship among the variables under consideration. The results below are the co-integration results of Colombia and Chile.

According to the results of trace and Maximum eigenvalues tests, there is at least one cointegration vector among the GDPPC for Colombia and global oil prices 1% significance level *(See Appendix Table A.6)*. For Chile, the test static is very close but still lower than the critical values *(See Appendix Table A.7)*. Therefore, the null of at most one co-integrating vector cannot be rejected. The results for Chile indicate the existence of a weak form of cointegration. This suggested that short-run shocks may not necessarily have affected the movement in the specific series and coverage in the long run. Thus, it is worth examining the long-run relationship further.

4.7 VAR

Before running the unrestricted VAR, we need to determine the optimal lag that best fits the model data using the information criterion procedure. This is carried out by implementing several methods such as Akaike Information Criterion (AIC), Schwartz Information Criterion (SIC), or Hannan-Quinn Information Criterion (HQIC). Since our data set is small we set a maximum number of lags to 5 and the AIC criterion for order selection. Below we have the results of different lag selection criteria.

VAR Order Selection (* highlights the minimums)

	AIC	BIC	FPE	HQIC
0	-5.283	-5.189	0.005078	-5.284
1	-8.459	-8.176	0.0002143	-8.462
2	-9.140	-8.668	0.0001131	-9.145
3	-8.900	-8.240	0.0001594	-8.907
4	-10.74	-9.893	3.136e-05	-10.75
5	-11.65*	-10.62*	1.952e-05*	-11.67*

VAR Order Selection (* highlights the minimums)

	AIC	BIC	FPE	HQIC
0	-5.449	-5.355	0.004301	-5.450
1	-8.134	-7.851	0.0002966	-8.137
2	-8.355	-7.883*	0.0002480*	-8.360
3	-7.935	-7.275	0.0004184	-7.943
4	-7.673	-6.824	0.0006751	-7.682
5	-8.874*	-7.835	0.0003148	-8.885*

Figure 4: Optimal lag order for Colombia(left) and Chile(right)

The results convey the relationship between oil prices and GDPPC when GDPPC is the dependent variable. For Colombia, the statistically significant lags at 5% levels for oil prices have a negative coefficient and positive for GDPPC lags *(See Appendix Table A.8)*. In the case of Chile, only the first GDPPC lag is positive and significant and the remaining lags show no causal effect on the values of the GDPPC *(See Appendix Table A.9)*.

4.8 VECM

Although, we observed a weak form of cointegration between the global oil prices and the GDPPC in both nations we still decided to estimate the VECM. This will enable us to extract valuable information for short-run dynamics in absence of co-integration. Since the error correction term (ECT) measures the speed of adjustment to the equilibrium level.

Det. terms outside the coint. relation & lagged endog. parameters for equation GDPPC

	coef	std err	z	P>|z|	[0.025	0.975]
L1.GDPPC	2.4563	0.191	12.838	0.000	2.081	2.831
L1.Oil_price	-1.6674	0.156	-10.691	0.000	-1.973	-1.362
L2.GDPPC	2.5856	0.202	12.806	0.000	2.190	2.981
L2.Oil_price	-1.6080	0.131	-12.267	0.000	-1.865	-1.351
L3.GDPPC	-0.0492	0.138	-0.357	0.721	-0.320	0.221
L3.Oil_price	-0.3288	0.053	-6.243	0.000	-0.432	-0.226
L4.GDPPC	-2.2823	0.186	-12.245	0.000	-2.648	-1.917
L4.Oil_price	0.5921	0.046	12.928	0.000	0.502	0.682
L5.GDPPC	-0.9986	0.126	-7.925	0.000	-1.246	-0.752
L5.Oil_price	0.0579	0.046	1.258	0.208	-0.032	0.148

Loading coefficients (alpha) for equation GDPPC

	coef	std err	z	P>|z|	[0.025	0.975]
ec1	-0.2215	0.056	-3.977	0.000	-0.331	-0.112

Loading coefficients (alpha) for equation Oil_price

	coef	std err	z	P>|z|	[0.025	0.975]
ec1	-0.6085	0.062	-9.846	0.000	-0.730	-0.487

Cointegration relations for loading-coefficients-column 1

	coef	std err	z	P>|z|	[0.025	0.975]
beta.1	1.0000	0	0	0.000	1.000	1.000
beta.2	-2.0732	0.003	-795.106	0.000	-2.078	-2.068

Figure 5: VECM results for Colombia

The results of VECM for Colombia show that most of the annual lagged values of global oil prices and GDPPC are statistically significant as a determinant of the GDPPC. The coefficients of the lagged values possess positive and negative signs; it implies a mixed effect of shocks on the GDPPC of that nation. The transmission rates tend to be higher for the GDPPC than oil prices as well. This may be related to the relative volatility of local markets and other factors that affect economic activity. Regarding the ECT, the coefficients of the ECT for the GDPPC are statistically significant and with a negative sign. This indicates that a 1% shock to the oil prices results in the GDPPC falling with a speed of 0.22% every year to correct and restore equilibrium.

Det. terms outside the coint. relation & lagged endog. parameters for equation GDPPC

	coef	std err	z	P>|z|	[0.025	0.975]
L1.GDPPC	0.5501	0.349	1.577	0.115	-0.134	1.234
L1.Oil_price	0.1566	0.230	0.682	0.495	-0.293	0.607
L2.GDPPC	-1.5995	0.903	-1.772	0.076	-3.369	0.170
L2.Oil_price	0.4936	0.238	2.075	0.038	0.027	0.960
L3.GDPPC	-1.3271	0.531	-2.497	0.013	-2.369	-0.285
L3.Oil_price	0.4237	0.197	2.146	0.032	0.037	0.810
L4.GDPPC	-0.1021	0.343	-0.298	0.766	-0.774	0.569
L4.Oil_price	0.5381	0.280	1.923	0.054	-0.010	1.086
L5.GDPPC	-1.9554	1.029	-1.900	0.057	-3.973	0.062
L5.Oil_price	0.9054	0.425	2.130	0.033	0.072	1.739

Loading coefficients (alpha) for equation GDPPC

	coef	std err	z	P>|z|	[0.025	0.975]
ec1	0.0089	0.005	1.920	0.055	-0.000	0.018

Loading coefficients (alpha) for equation Oil_price

	coef	std err	z	P>|z|	[0.025	0.975]
ec1	-0.0093	0.008	-1.121	0.262	-0.025	0.007

Cointegration relations for loading-coefficients-column 1

	coef	std err	z	P>|z|	[0.025	0.975]
beta.1	1.0000	0	0	0.000	1.000	1.000
beta.2	4.9902	0.922	5.411	0.000	3.183	6.798

Figure 6: VECM results table Chile

For Chile, most of the lagged values are statistically insignificant and tend to have positive coefficients for oil prices and negative for the GDPPC lagged values. This indicates oil price shocks result in increasing the value of its GDPPC. Similarly, the transmission rates are much higher for GDPPC lagged values than oil prices. Here we can see that the ECT for the GDPPC is positive and statistically insignificant at a 5% level. This implies that the process is not converging in the long run and there may be are some instabilities in the process.

Model evaluation indicates that the residuals are normally distributed are found to be serially correlated. This could be due to the small sample size and missing factors within the model that could have explained the observed variations.

4.9 Forecasting, Impulse Response Functions and Variance Decomposition Analysis

The forecast outlook for the GDPPC of both nations for the next 20 periods shows that the GDPPC level will decline in values for almost 5 periods into the future but will possibly rebound back up afterward. However, the standards deviation of the forecast is much wider for Chile than for Colombia. In addition, Chile's forecast indicates a downward spiral towards the end of the forecast horizon. Therefore, Chile's GDPPC forecast is more likely to lead to a less uncertain outcome.

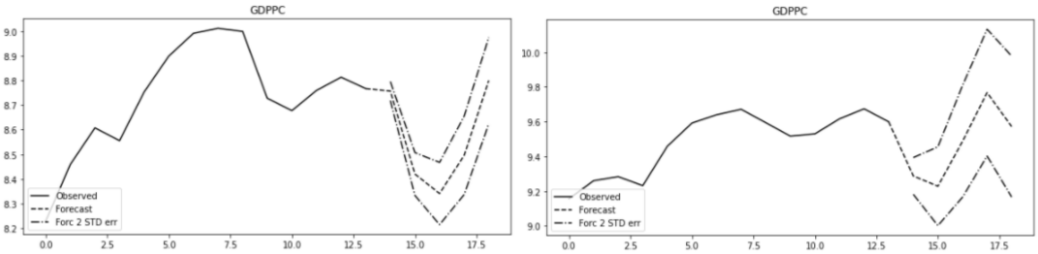

Figure 7: Forecast for Colombia(left) and Chile(right)

The study further examines the dynamics among the variables with the impulse response functions (IRF) and variance decomposition. In Fig 8, we have the Impulse Response Function with the output being GDPPC in Chile and Colombia and the input being a change of the oil price. We find that a one standard deviation shock on the oil prices negatively impacts the GDPPC in Colombia in the short run, the negative impact tends to come back to normal and then goes in the negative direction again in the long run. The impact is cyclical, starting with a negative impact followed by a return to normal in the middle and a negative impact again in the long run. In Chile, the impact of a one standard deviation shock in oil prices is positive for the GDPPC in the short run as well as in the long run in general.

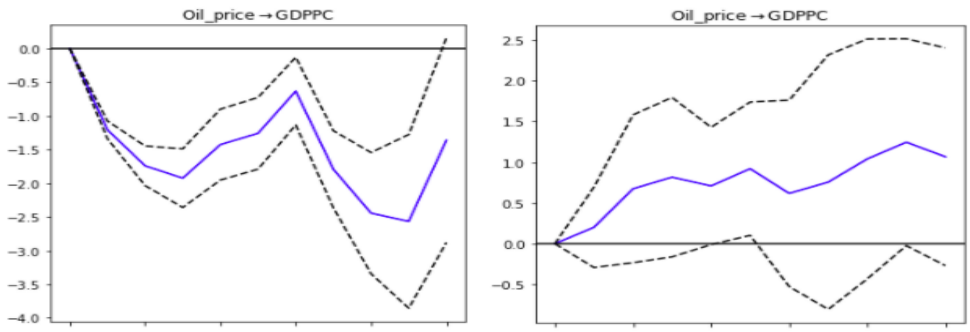

Figure 8: IRF Colombia(left) and Chile(right)

Variance decomposition on the VAR models for Colombia indicates that the values of GDPPC are mostly affected by its lagged values. On the other hand, the GDPPC values for Chile are mostly determined by itself but after the 8th period, the effect of global oil prices significantly increases and is almost equal to the effect of the lagged values of GDPPC by the end of the 20th period.

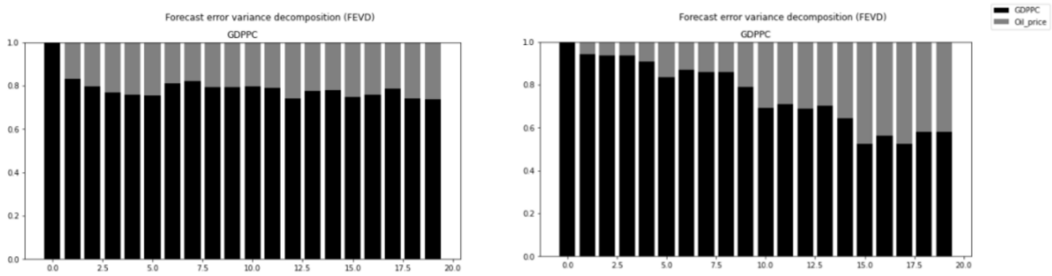

Figure 9: Variance decomposition for Colombia(left) and Chile(right)

4.10. Summary VAR and VECM

In general, there seems to be a long-run relationship between the global oil prices and GDPPC for Colombia but seems to be weaker for Chile. OLS results show a positive and significant effect of oil prices on GDPPC for both nations. We found cointegration relations between Colombia GDPPC and oil prices but observed a weak form of cointegration for Chile. The VECM provided a glimpse of the long-run relationship between oil prices and GDPPC to some extent.

In the study, we observed that global oil price shocks show mixed effects of the levels GDPPC and economic activity in Colombia but the GDPPC values tend to fall after the shock in order to restore market equilibrium. In the case of Chile, the estimates show no signs that oil price shocks affect the level of GDPPC since most of the lagged values are insignificant. In addition, the error correction process fails to converge in the long run.

The shock response for Colombia GDPPC has a decreasing trend from initiation. In comparison to Chile, the response exhibits a persistent and increasing trend. Moreover, Colombia's GDPPC is mostly affected by its own values, however in the case of Chile, even though at first it's mostly determined by its own values, as the time period increases the majority of the influence on the GDPPC comes from the variations caused in the global oil prices.

This part of the analysis reveals that oil price shocks pose a significant impact on the economic activity of an oil-exporting country of Colombia in the long run. The economy tends to decline to correct for market equilibrium and normalcy in the long run to go in tandem with the fluctuating global oil prices. However, the impacts of oil shocks on the oil-importing country Chile tends to be less significant and the economic activity response magnitude is less severe compared to Colombia's.

5. Evaluating the impact of oil price shocks on macroeconomic variables

5.1. Data sources and Methodology

This project also applied the SVAR model over the period 2000 to 2020, which provides 21 annual observations. The macroeconomic indicators included: crude oil price, GDP per capita, Inflation, Interest rate, and Industrial production index. Again data is obtained from The World Bank and Federal Reserve Economic Data (FRED) through python API's. The SVAR is expressed as follows:

$$Y_t = (OIL_t, GDPPC_t, INF_t, IR_t, IPI_t)$$

$$A_0 Y_t = \alpha + \sum_{i=1}^{p=5} A_i \, Y_{t-i} + e_t$$

α is a vector of constants, A_i is a matrix consisting of coefficients and e_t is the error rate. The SVAR assumption is that A_i has a recursive structure and the reduced model form residuals can be decomposed according to $e_t = A_0{}^{-1} e_t$. This implies that restriction placed on matrix A_i infer the variations caused in global oil prices are exogenous in relation to the other macroeconomic variables included in the SVAR model (Blanchard & Quah, 1989). According to Cholesky triangular factorization (Haddad, 2009), oil prices are the major exogenous variable and the rest of the variables are listed according to their order of effect. Then the SVAR estimates of the short-run pattern can be shown as follows:

$$\begin{pmatrix} Oil_t \\ GDPPC_t \\ INF_r \\ IR_t \\ IPI_t \end{pmatrix} = \begin{bmatrix} \alpha_{11} & 0 & 0 & 0 & 0 \\ \alpha_{21} & \alpha_{22} & 0 & 0 & 0 \\ \alpha_{31} & \alpha_{32} & \alpha_{33} & 0 & 0 \\ \alpha_{41} & \alpha_{42} & \alpha_{43} & \alpha_{44} & 0 \\ \alpha_{51} & \alpha_{52} & \alpha_{53} & \alpha_{54} & \alpha_{55} \end{bmatrix} \begin{pmatrix} e_t^{Oil-shock} \\ e_t^{GDPPC-shock} \\ e_t^{INF-shock} \\ e_t^{IR-shock} \\ e_t^{IPI-shock} \end{pmatrix}$$

Estimated A matrix:

	Oil_price	GDPPC	CPI	IR	PrIdx
Oil_price	1.00000	0.00000	0.00000	0.00000	0
GDPPC	0.17790	1.00000	0.00000	0.00000	0
CPI	3.93081	-0.51638	1.00000	0.00000	0
IR	4.78886	0.07041	0.52038	1.00000	0
PrIdx	0.06979	0.07645	-0.06036	0.06478	1

Estimated A matrix:

	Oil_price	GDPPC	CPI	IR	PrIdx
Oil_price	1.0000	0.0000	0.00000	0.0000	0
GDPPC	0.1072	1.0000	0.00000	0.0000	0
CPI	-0.6313	0.3075	1.00000	0.0000	0
IR	0.1137	0.1304	0.54635	1.0000	0
PrIdx	0.2328	0.1092	-0.05443	0.1583	1

Figure 10: SVAR matrix for Chile(top) and Colombia(bottom)

The effect of global oil price shocks on macroeconomic variables is displayed in the above table in the first column of each table. In the case of Chile, oil price shocks have a positive effect on all of the macroeconomic variables and the magnitude is much larger for inflation and interest rates. Results are similar in the case of Colombia with a positive effect on the indicators except for inflation. The consumer price index which is the proxy for inflation is shown to be affected negatively by oil price shocks. In addition, the magnitude of the oil price change impact tends to be much lower in Colombia than in Chile.

5.2. IRF and FEVD analysis

The impulse response function for Colombia shows that following oil price shocks inflation, interest rates, and GDPPC remain persistent with their long-run mean implying that effects may be insignificant. However, inflation is slightly affected significantly for the 8 periods following oil price shocks.

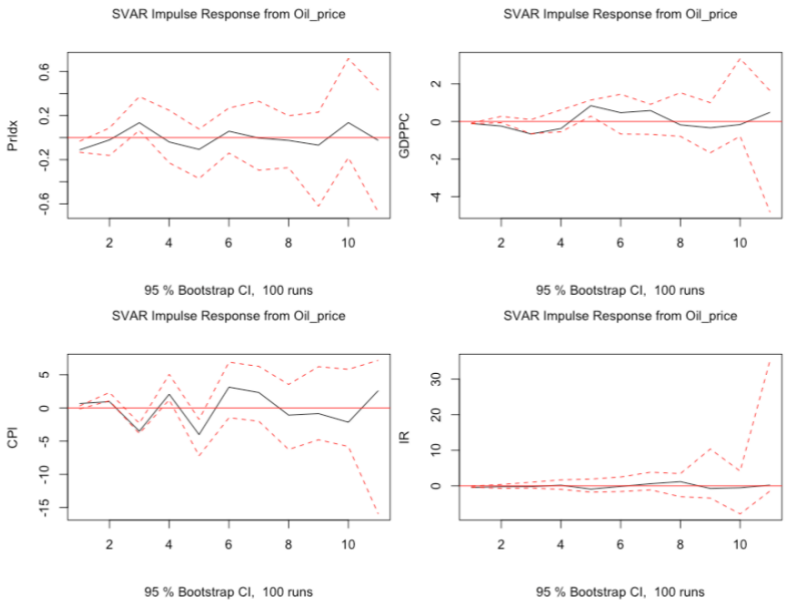

Figure 11: SVAR impulse response function for Colombia

The macroeconomic response for the short-term oil price shocks for Chile shows no signs of initial responses. All the variables maintain zero response magnitude to the price shocks. This could indicate either oil price shock has little to no significant effect on the variables or it could be indeterminate due to the small size employed.

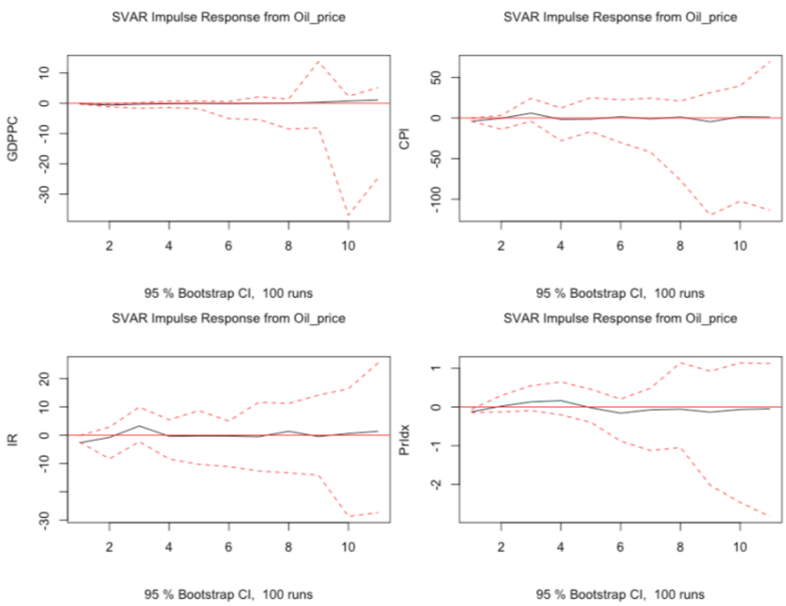

Figure 12: SVAR impulse response function for Chile

From the FEVD for Colombia above we notice that the Production Index explains more than 50% of the variation of the different macroeconomic indexes after the 3rd period. The production index being a leading economic indicator, the above results are in line with the expectations

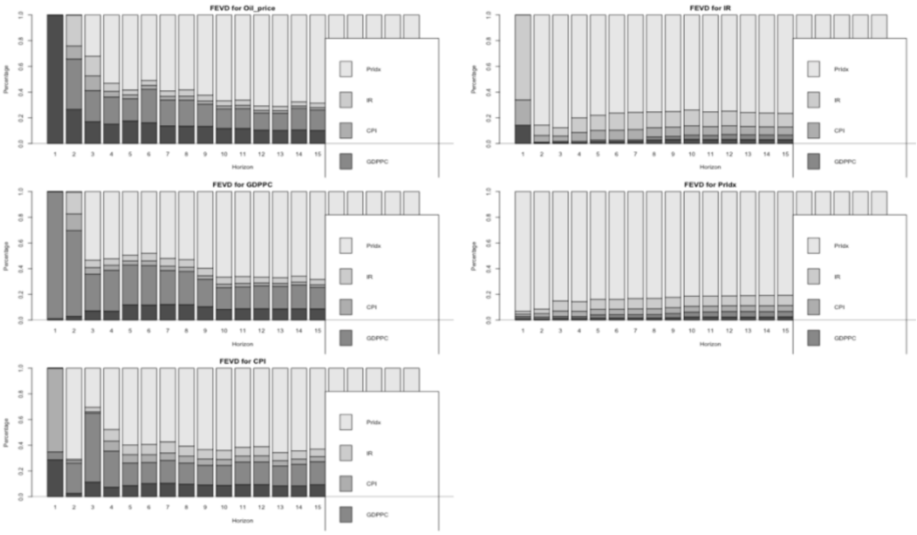

Figure 13: SVAR FEVD Colombia

For Chile, the GDPPC variable has a large impact on the change of its own shocks and the other variables in the SVAR model. The production index, as well, explains a significant percentage of the variation of the different macroeconomic indexes as shown in the below charts.

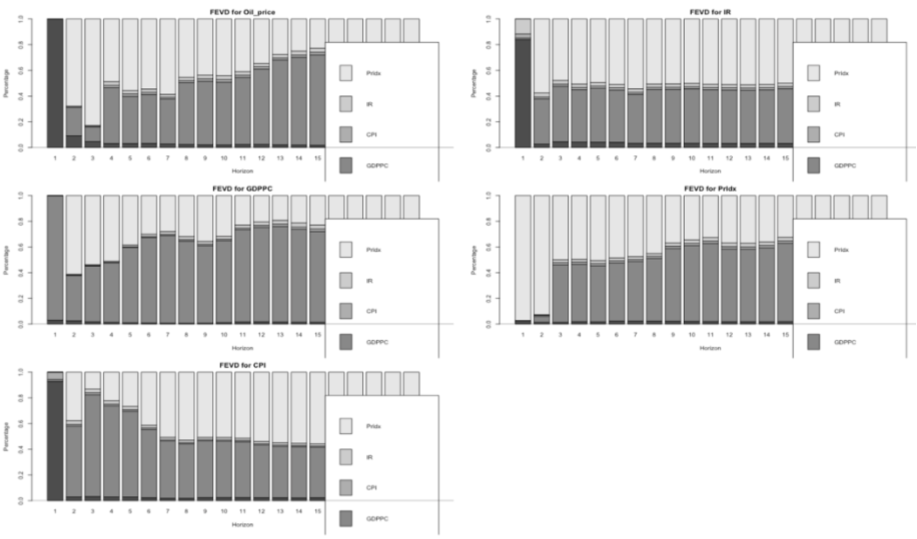

Figure 14: SVAR FEVD Chile

6. Conclusion

This small-scale empirical research project examines the impact of global oil price shocks on macroeconomic factors in selected Latin American emerging economies. The study considers Colombia a net oil-exporting country and Chile a net oil importing one. The study utilized annual data over the period 2000 to 2020.

The study utilized the Structural VAR approach (SVAR) to investigate the effect of oil price shocks on the level of economic activity. These factors include GDP per capita, Consumer price index (inflation), and level industrial manufacturing and production. This study examined the long-run effect and the short-run impulse response function of these macroeconomic indicators in response to global oil price shocks.

Existing studies have shown that oil price shocks positively affect the economic growth of an oil-exporting nation. However, our findings show the opposite. Oil price shocks significantly and positively affected all the macroeconomic variables for Chile. It also revealed that inflation and interest rate show a larger magnitude of effect among the variables. However, in case of Colombia, oil-exporting nations, oil price shocks have a negative effect on inflation. Although the effect is positive on the rest of the indicators, it has a lower magnitude than Chiles's. Our results are in accord with such studies of (Bekhet & Yusop, 2009) (Alley et al., 2014).

The Impulse Response Function shows that a shock to the global oil price affects oil prices changes negatively with little recovery after some period but with a further decline in the future. The results of the impulse response function for Colombia shows a significant variation and fluctuations on inflations for certain periods of time, however response from the other indicators remain persistent with the long-run mean. While in Chile the effect of the impulse response function of oil price shocks is significantly low on the macroeconomic variables and shows no discernable signs of variations over the short and long-run periods.

In addition, FEVD results reveal that industrial production is a major factor impacting the variation observed in the other macroeconomic indicators in Colombia. For Chile, however, GDP per capita plays a huge role in determining not only its own price innovations but also has a significant effect on the dynamics of the other macroeconomic factors.

7. Policy Recommendations and Risk Management

Our results reveal that under the 5% level of significance oil price increases have a comparable effect on the GDPPC of Colombia and Chile. In addition, oil prices Granger causes GDPPC in both emerging economies indicating a positive relationship, however, the GDPPC of the oil-importing nation tends to correct itself to correct for market equilibrium in the short run.

Moreover, our findings suggest that global oil price shocks are a significant cause of macroeconomic variation in oil-importing and exporting emerging economies. Lack of economic stability causes prices changes to suddenly affect macroeconomic variables such as inflation, interest rates, and industrial production capacity (Omojolaibi, 2013). It's also important to highlight that net-oil importing and exporting countries can differ in their response to global oil price shocks based on several factors: such as level of energy consumption, the proportion of oil exports from the GDP, oil dependence in the energy mix, and the conditions of the balance of trade. Therefore, understanding the macroeconomic structure of an economy significantly helps in implementing effective economic policies.

Such policy recommendations for net-exporting emerging economies to combat oil price shocks include passing price increases, hedging with futures oil contracts, decreasing the high dependency on petroleum and oil products, and investing in sustainable and alternative energy. In the case of net-importing nations policies to reduce the cost of oil import by the use of hedging can assist in mitigating the negative effect of oil price increase such as inflation. If oil prices are presumed to increase in the future, then commercial or government companies can purchase oil beforehand and this can help the government to maintain a steady price for the consumers. Diversifying energy consumption into non-petroleum sources of energy can also help in reducing the high dependence on oil.

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Appendix

```
adf_test(Colombia_df_log['GDPPC'])

Augmented Dickey-Fuller Test:
ADF test statistic      -6.130243e+00
p-value                  8.436064e-08
# lags used              8.000000e+00
# observations           1.100000e+01
critical value (1%)     -4.223238e+00
critical value (5%)     -3.189369e+00
critical value (10%)    -2.729839e+00
Strong evidence against the null hypothesis
Reject the null hypothesis
Data has no unit root and is stationary
```

```
adf_test(Colombia_diff['GDPPC'])

Augmented Dickey-Fuller Test:
ADF test statistic      -7.698123e+00
p-value                  1.361969e-11
# lags used              7.000000e+00
# observations           1.000000e+01
critical value (1%)     -4.331573e+00
critical value (5%)     -3.232950e+00
critical value (10%)    -2.748700e+00
Strong evidence against the null hypothesis
Reject the null hypothesis
Data has no unit root and is stationary
```

Table A.1: ADF test of GDPPC I(0) and I(2) for Colombia

```
adf_test(Chile_df_log['GDPPC'])

Augmented Dickey-Fuller Test:
ADF test statistic      -3.811287
p-value                  0.002794
# lags used              8.000000
# observations          11.000000
critical value (1%)     -4.223238
critical value (5%)     -3.189369
critical value (10%)    -2.729839
Strong evidence against the null hypothesis
Reject the null hypothesis
Data has no unit root and is stationary
```

```
adf_test(Chile_diff['GDPPC'])

Augmented Dickey-Fuller Test:
ADF test statistic      -1.447819
p-value                  0.559149
# lags used              7.000000
# observations          10.000000
critical value (1%)     -4.331573
critical value (5%)     -3.232950
critical value (10%)    -2.748700
Weak evidence against the null hypothesis
Fail to reject the null hypothesis
Data has a unit root and is non-stationary
```

Table A.2: ADF test of GDPPC I(0) and I(2) for Chile

```
adf_test(Colombia_df_log['Oil_price'])

Augmented Dickey-Fuller Test:
ADF test statistic      -0.785477
p-value                  0.823351
# lags used              8.000000
# observations          11.000000
critical value (1%)     -4.223238
critical value (5%)     -3.189369
critical value (10%)    -2.729839
Weak evidence against the null hypothesis
Fail to reject the null hypothesis
Data has a unit root and is non-stationary
```

```
adf_test(Colombia_diff['Oil_price'])

Augmented Dickey-Fuller Test:
ADF test statistic      -1.602408e+01
p-value                  6.158848e-29
# lags used              7.000000e+00
# observations           1.000000e+01
critical value (1%)     -4.331573e+00
critical value (5%)     -3.232950e+00
critical value (10%)    -2.748700e+00
Strong evidence against the null hypothesis
Reject the null hypothesis
Data has no unit root and is stationary
```

Table A.3: ADF test at I(0) and I(2) for global oil prices

OLS Regression Results

Dep. Variable:	GDPPC	R-squared:	0.687
Model:	OLS	Adj. R-squared:	0.669
Method:	Least Squares	F-statistic:	39.48
Date:	Sun, 23 Jan 2022	Prob (F-statistic):	6.34e-06
Time:	11:19:09	Log-Likelihood:	-0.37070
No. Observations:	20	AIC:	4.741
Df Residuals:	18	BIC:	6.733
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	5.0566	0.547	9.245	0.000	3.908	6.206
Oil_price	0.8460	0.135	6.283	0.000	0.563	1.129

Omnibus:	1.585	Durbin-Watson:	0.283
Prob(Omnibus):	0.453	Jarque-Bera (JB):	0.981
Skew:	0.168	Prob(JB):	0.612
Kurtosis:	1.968	Cond. No.	40.5

Table A.4: OLS table Colombia

OLS Regression Results

Dep. Variable:	GDPPC	R-squared:	0.636
Model:	OLS	Adj. R-squared:	0.616
Method:	Least Squares	F-statistic:	31.42
Date:	Sun, 23 Jan 2022	Prob (F-statistic):	2.55e-05
Time:	11:26:46	Log-Likelihood:	-2.3427
No. Observations:	20	AIC:	8.685
Df Residuals:	18	BIC:	10.68
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	5.8511	0.604	9.694	0.000	4.583	7.119
Oil_price	0.8330	0.149	5.606	0.000	0.521	1.145

Omnibus:	2.876	Durbin-Watson:	0.306
Prob(Omnibus):	0.237	Jarque-Bera (JB):	2.366
Skew:	0.768	Prob(JB):	0.306
Kurtosis:	2.305	Cond. No.	40.5

Table A.5: OLS table Chile

Johansen Cointegration tests; at 1% level of significance

Johansen cointegration test using trace test

r_0	r_1	test statistic	critical value
0	2	26.75	23.15
1	2	5.676	6.635

Johansen cointegration test using maximum eigenvalue test

r_0	r_1	test statistic	critical value
0	1	21.08	21.75

Table A.6: Chile and oil prices

Johansen cointegration test using trace test

r_0	r_1	test statistic	critical value
0	2	22.95	23.15

Johansen cointegration test using maximum eigenvalue test

r_0	r_1	test statistic	critical value
0	1	15.40	21.75

Table A.7: Chile and oil prices

```
  Summary of Regression Results
==================================
Model:                         VAR
Method:                        OLS
Date:           Sun, 23, Jan, 2022
Time:                     11:03:55
--------------------------------------------------------------------
No. of Equations:         2.00000    BIC:                   -10.6157
Nobs:                     15.0000    HQIC:                  -11.6652
Log likelihood:           66.8378    FPE:                1.95241e-05
AIC:                     -11.6541    Det(Omega_mle):     6.49841e-06
--------------------------------------------------------------------
Results for equation GDPPC
==============================================================================
                 coefficient       std. error           t-stat            prob
------------------------------------------------------------------------------
const               1.659271         1.443552            1.149           0.250
L1.GDPPC            1.767052         0.580853            3.042           0.002
L1.Oil_price       -0.913506         0.308745           -2.959           0.003
L2.GDPPC            1.577851         1.012733            1.558           0.119
L2.Oil_price       -0.907397         0.440201           -2.061           0.039
L3.GDPPC            0.387835         0.557186            0.696           0.486
L3.Oil_price       -0.266068         0.276527           -0.962           0.336
L4.GDPPC           -1.443616         0.499998           -2.887           0.004
L4.Oil_price        0.445150         0.189899            2.344           0.019
L5.GDPPC           -0.759243         0.675798           -1.123           0.261
L5.Oil_price        0.105399         0.201674            0.523           0.601
==============================================================================
```

Table A.8: VAR table for Colombia

```
  Summary of Regression Results
==================================
Model:                         VAR
Method:                        OLS
Date:           Sun, 23, Jan, 2022
Time:                     11:33:32
--------------------------------------------------------------------
No. of Equations:         2.00000    BIC:                   -7.83522
Nobs:                     15.0000    HQIC:                  -8.88476
Log likelihood:           45.9846    FPE:                0.000314846
AIC:                     -8.87370    Det(Omega_mle):     0.000104793
--------------------------------------------------------------------
Results for equation GDPPC
==============================================================================
                 coefficient       std. error           t-stat            prob
------------------------------------------------------------------------------
const               3.976133         1.900064            2.093           0.036
L1.GDPPC            1.296411         0.495959            2.614           0.009
L1.Oil_price       -0.235929         0.150336           -1.569           0.117
L2.GDPPC           -0.337681         0.688515           -0.490           0.624
L2.Oil_price        0.129233         0.186810            0.692           0.489
L3.GDPPC           -0.452074         0.688455           -0.657           0.511
L3.Oil_price        0.028586         0.187807            0.152           0.879
L4.GDPPC            0.370493         0.688117            0.538           0.590
L4.Oil_price        0.034691         0.177116            0.196           0.845
L5.GDPPC           -0.422243         0.565130           -0.747           0.455
L5.Oil_price        0.309508         0.268127            1.154           0.248
==============================================================================
```

Table A.9: VAR table for Chile