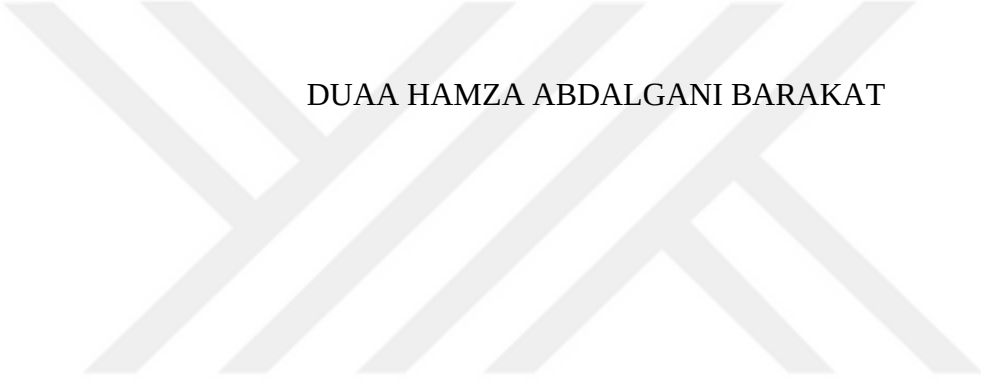


ERRATIC CRUDE OIL PRICES FLUCTUATIONS EFFECTS ON THE ECONOMIC
DEVELOPMENT OF TURKEY: THE CASE OF CORONAVIRUS PANDEMIC
(COVID-19)



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YEDITEPE UNIVERSITY
GRADUATE SCHOOL OF SOCIAL SCIENCES
İSTANBUL, 2022

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İSTANBUL, 2022

PLAGIARISM

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.



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ÖZET

Tezde petrol ithal eden bir ülke olarak Türkiye ekonomisi, makroekonomik toplamının petrol fiyatlarındaki dalgalanmalara verdiği tepkiye bakılarak incelenmiştir. Ayrıca tez, pandemi sonrası koronavirüsün enerji ve hisse senedi piyasaları üzerindeki etkilerini tartışacaktır. Ayrıca tez, ham petrol türleri, üretimi ve diğer pazarlarla ilişkisi dahil olmak üzere birçok yönü analiz edecektir. Makroekonomik büyüklükler ise toplam sanayi üretimi endeksi, TÜFE, nominal döviz kuru, toplam petrol ve diğer sıvılar üretimi ve doğal gaz ithalat fiyatları ile temsil edilecektir. Model 1 için kullanılan hata düzeltme modeli: Brent petrol fiyatına yönelik şokların Türkiye'nin makroekonomik büyüklükleri üzerindeki etkisinin analizi. Model 2: Koronavirüs vakalarının ham petrol fiyatları, hisse senedi fiyatı oynaklığı (VIX) ve Borsa İstanbul Endeksi (BIST-100) üzerindeki etkilerini otoregresif dağıtılmış gecikme modeli kullanarak inceler. Araştırma, Brent petrol fiyatlarına ait bilgileri iki modelde kullanacak ekonometrik ve analitik alanlara sahiptir. İlk olarak, Kasım/2000'den Temmuz/2021'e kadar aylık gözlemleri analiz edecek olan Brent ham petrol fiyatı ile Türkiye ekonomik büyüklükleri arasındaki korelasyon. İkinci olarak, Türkiye'de ilk enfekte vakanın görüldüğü 11/Mart/2020 tarihinden 12/Nisan/2021 tarihine kadar geçen süreyi kapsayan günlük COVID-19 vakalarının petrol ve borsalar üzerindeki etkisinin tahmin edilmesi. Bu çalışma, COVID-19 pandemik değişimlerini dikkate alarak petrol fiyatları şoklarının Türkiye ekonomisi üzerindeki önemine dikkat çekerek mevcut literatüre katkı sağlayacaktır.

Anahtar Kelimeler: VIX, BIST-100, TÜFE, COVID-19, ARDL.

ABSTRACT

As an oil-importing nation, Turkey's economy is examined in the thesis by looking at its macroeconomic aggregate's response to oil price fluctuations. Furthermore, the thesis will discuss the post pandemic coronavirus effects on energy and stock markets. Moreover, the thesis will analyze many aspects including crude oil types, production, and its relationship with other markets. On the one hand, macroeconomic aggregates will be represented by the total industrial production index, CPI, nominal exchange rate, total petroleum and other liquids production, and natural gas import prices. Error correction Model utilized for model 1: Analyzing the impact of shocks to the price of Brent oil on Turkey's macroeconomic aggregates. Model 2: examines the effects of coronavirus cases of infection on crude oil prices, stock price volatility (VIX), and the Borsa Istanbul Index (BIST-100) using an autoregressive distributed lag model. The research has econometrical and analytical areas which will use information of Brent oil prices in two models. Firstly, the correlation between Brent crude oil price and Turkish economic aggregates that will analyze monthly observations from Nov/2000 to July/2021. Secondly, estimating COVID-19 daily infected cases influence on oil and stock markets covering the period from the first infected case in Turkey 11/March/2020 until 12/April/2021. This study will add to the existing literature by bringing awareness to the significance of oil prices shocks on the Turkish economy, taking into consideration COVID-19 pandemic alterations.

Keywords: VIX, BIST-100, CPI, COVID-19, ARDL.

JEL codes: G41, G15, C32, Q41

PREFACE

Energy market is considered to be the most sensitive market, since energy is the most essential input for major markets such as petrochemicals, commodity, and many other markets. Therefore, the energy market, specifically, crude oil market should be organized professionally to achieve the aim of efficient utilization for these scarce resources in order to attain the economic development of the world. The study aims to investigate the relationship among Brent oil prices and economic indicators of Turkey by applying autoregressive distributed lag (ECM) model. Moreover, the study points to look at cointegration between Brent crude oil price, CPI, nominal exchange rate, Total Petroleum and Other Liquids Production, natural gas imports prices, and Total Industrial Production Index. The second contribution of the thesis is to test the eschewing of COVID-19 effect on Energy and Stock Market Indexes using ARDL Model. Several economists had analyzed various facts of Turkish economy at different periods of time, corresponding to crude oil prices fluctuations. In earlier research with various economic elements, the specific effect of crude oil price shocks on the Turkish economy has not been described. The research will be done basically by measurable and econometrical strategies. Moreover, the observational relationship among the factors will be tested by Wald test, Bound test, and Johansen cointegration test. E-views software for econometric analysis will be employed.

DEDICATION

I dedicate this thesis to God Almighty my creator, my strong pillar, my source of inspiration, wisdom, knowledge and understanding. He has been the source of my strength throughout this program and on His wings only have I soared. This work is also dedicated to my parents, Dr. Hamza BARAKAT and Israa ALALAMI, who have always loved me unconditionally and whose good examples have taught me to work hard for the things that I aspire to achieve. To my daughter Eiala HASAN who has been a constant source of support and encouragement during the doctoral program. I am truly thankful for having you in my life. Thank you. My love for you all can never be quantified. God bless you. Last, I wish to express my sincere thanks to all my family members and friends for their timely help, moral support and encouragement.

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CHAPTER 1

INTRODUCTION

1.1 Background

Scientists describe petroleum in a number of ways. Subsequently, since it is a natural item forming a portion of rocks, there is no uniformity. Petra implies crude and oleum implies oil. The word petroleum is determined from two Latin terms. Rock oil or crude oil is called petroleum. It can be a nonspecific word that encompasses an enormous number of hydrocarbon compounds that are naturally occurring carbon and hydrogen derivatives. Petroleum, depending on the proportion of the hydrocarbon sequence specifying its physical and chemical highlights, is graded as aliphatic, aromatic, and cationic. Over geographical ages, the production of crude oil in its disposal and the shift of biomass date back to 200 million years ago. Subsequently, the entire quantity of oil and gas dwells within the seafloor of the earth and is negligible.

Economists pay considerable attention to crude oil price fluctuations impact on the worldwide economy as oil is a major asset for industrial businesses. Many analysts, like (Hamilton, 1983; Kilcia 2019, Al Rasasi and Yilmaz 2016), advised that changes in the price of oil had an impact on cyclical changes in the economy. These effects may be different between countries that import and export oil. The converse should be true when the price of oil decreases, while an increase in oil prices can be considered as a great news in oil exporting countries and it will be a terrible news for oil importing countries. The oil and energy markets as factor in supply, demand, and price level have an impact on economic activity. In economic Hamilton (1983) is the first contributor in the field of crude oil price shocks on the economic situation of USA after World War II. Hamilton (1983) confirmed the negative relationship between the increase in oil prices and US economic activities, which cause the seven downturns of US eight crisis. Because of its position as an input in other industries, crude oil is one of the most important energy sources. It can also be said that oil price fluctuations have a potential effect on the input and production costs. For example, oil imports have become one of the most imperative import items in Turkey, an oil importing state, with a level of 422,595 barrels per day. As detailed by the Organization

of Petroleum Exporting Countries, 90 % of Turkey's oil needs are met by imports (OPEC, 2020a).

The fundamentals of economic growth are the effective allocation of capital and the long-term stabilization of demand. The realization of countries' strong economic growth over the next decades allows for fast expansion in the energy sector. The energy assets accessibility is constrained and may not be adequate within the long run to support economic improvement which leads to extensive energy import reliance. Subsequently, oil price reduction is considered significant for the macroeconomic indicators in Turkey.

Attainable energy contributes to diminishing destitution, expanding efficiency and upgrading life quality. In UK, families that spend less than 10% of their wage on warming their homes suffer from oil poverty (BP, 2019). Some poor in Turkey do not have the minimum energy resources. Moreover, need to get a dependable energy may be an extreme impediment to economic growth. With some countries consuming large amounts per capita, there are significant variations in energy consumption levels around the world, while others tend to use conventional sources of energy. The provision of energy has become a matter of significant global importance.

In 2019, primary energy consumption increased by 2.9 percent, hit 14 billion tons of oil, doubled its ten-year average by 1.5 percent, and has been the highest rate since 2010 (Anadolu Agency, 2019). The rise in energy demand was powered by natural gas, which accounted for over 40 % of the increase. Moreover, as reported in the Anadolu Agency's energy survey, oil consumption increased by 1.4 million barrels/day. The main contributors to this development were China's \$680,000 and \$500,000. However, global oil production grew to 2.2 million by US production. Global consumption of primary energy is projected to rise by 1.6 percent, including 39% increase in world consumption of oil by 2030. In non-OECD countries, approximately 96 % of the growth is non-OECD energy usage is expected to be 69% above the 2019 level by 2030, with an average growth of 2.7%. The energy demand of the OECD is 4% higher in 2030 than in 2019. There is a decreasing drift in OECD per capita energy consumption (BP, 2019).

The negative or positive impacts of oil price shocks on the economies is based on its situation as trader or importer of oil. The increase in oil price moves through trading the

profits from importing to exporting nations. The global economic development has continuously affected the consumption elasticity of net importing nations. The negative effect of high oil prices appears in the long run.

Moreover, the latest important event of coronavirus spreads across the world at the beginning of 2020, limiting travel and universal economic activity, global oil demand decreased. In recent March, 40-60 percent fewer flight movements were recorded as the pandemic spread. More than 80% of travel trips between all countries were restricted in April, as stated by the International Energy Agency (IEA, 2020). Oil price changes started to respond to COVID-19 in the beginning of March 09, 2020, which is 49 days after the first case of infection was recorded according to the checking report (WHO, 2020).

This pandemic leads to a growing perception of risk and uncertainty in financial markets. As a result, spontaneous decision-making is becoming less precise in determining the duration and depth of the economic impacts of the health crisis. COVID-19 breaks out in Wuhan, China, and quickly spreads throughout the world. On March 11, 2020, the virus had infected over 100,000 persons in over 100 nations, killing thousands of people. WHO (2020) declared the new coronavirus pandemic based on those findings. The first infected case in Turkey was announced on March 11, 2020. In this period, the government poised a curfew on the whole country which negatively affect export and import trading, tour sector, agriculture, manufacturing and transportation, leads to poverty and overloading hospitals. In addition, beginning in February 2020, crude oil and stock markets exposed to multiple shock waves, and financial volatility in BIST-100 stock exchange rise.

The present research examines how cases of COVID-19 crisis influence the Turkish stock exchange and energy markets. Here, in order to represent the stock market, BIST-100 and VIX will be used and for the energy market the research will use daily Brent oil prices. The Autoregressive Distributed Lag Model which allows investigating if the relationship among oil price, VIX, BIST-100, and COVID-19 converges towards a long-term balance will be used. The study concentrated on these indexes as they are the most affected during the pandemic period. A tremendous decrease in crude oil prices with low demand as of the curfew restrictions applied in Turkey, lead not only to depreciation in Turkish lira,

but also to a downturn in all economic sectors. Moreover, the pandemic leads to high uncertainty in economic activities which affected investors and traders' financial and economic expectations. On the other hand, the study examines the daily infected cases impact on stock and energy indexes, for that reason the study chose only these variables as they are available in daily basis, as most variables are most afforded in monthly or quarterly basis.

Based on the extensive literature review done for this study, we did not come across another thesis investigating a similar relationship for the same time period among COVID-19 crisis and stock and energy markets. As a result, this paper is going to be the first thesis investigating the effect of the pandemic on Turkey from March 11, 2020 to April 12, 2021, in the literature. As a result, we expand on Albulescu (2020a) and broaden his approach in a number of ways. Firstly, the study uses COVID-19 daily infected cases in Turkey and other dependent variables to look at the dynamic and long run correlation during the pandemic. Moreover, the thesis used the VIX volatility and BIST-100 as indexes for Turkey financial markets' volatility, and Brent fluctuations as a proxy for energy market prices swings. Based on our findings, it's critical to examine COVID-19's impact on a country's public health and well-being as well as its economics. Because following these economic shocks country's public health systems fail and result in the death of many citizens. According to McKibbin and Fernando (2020), if illnesses are caused by population growth in poor nations, poor public health may kill individuals, unless governments realized the need for public health and developed investment improvements, as a driver of GDP growth. McKibbin and Fernando (2020) gave some early estimations of the cost of the COVID-19 epidemic in terms of economic impacts of coronavirus transmission. Central banks must ensure that world economies should produce in the short term, while the long-term effects of the pandemic are more important. Moreover, the majority of sectors have realized negative returns specially tour sector, transport, and sport sectors losing the most from BIST indexes during the pandemic (Karaca, et.al. 2020).

The research objectives are to organize a hypothetical and explanatory examination to illustrate the impact of Brent oil price variances on CPI, Total petroleum and other liquids production, natural gas import prices, Total industrial production index, and nominal

exchange rate in Turkey by employing ECM model. Furthermore, the inquiry aims to look at long relationship between the parameters by Wald and Bound cointegration tests.

The thesis contributes to research field through testing the correlation among these economic parameters and crude oil prices in a comprehensive study for the Turkish economy for the period from Nov 2000 to July 2021. Besides that, the thesis will focus on the effect of coronavirus cases of infection on Brent oil prices, Volatility of stock price index (VIX), and Borsa Istanbul index (BIST-100) from 11 March/2020-12April/2021 using ARDL model. E-views software for econometric analysis will be used. Data for Brent oil price, CPI, nominal exchange rate, Total petroleum and other liquids production, natural gas import prices, Total industrial production index, and coronavirus active cases were accumulated from secondary sources that incorporate, IFS (2020); WHO (2021); CEIC (2020a); OECD (2020a, 2020b, 2020d); Federal Reserve Bank of St. Louis (2021); Ychart (2021); EIA (2021); Bloomberg.com (2021); and Investing (2021).

The study is divided into two parts. The first part investigates the link between Brent oil price swings and Turkey's economic indicators. The second part simulates the interaction between the prices of Brent oil, VIX index, and Borsa Istanbul index and COVID-19 pandemic problem. The time span under consideration is 21 years. The following chapter provides a survey of past research undertaken in the thesis's area of study. The third chapter is a detailed descriptive analysis of the data. Chapter 4 is a comprehensive study for coronavirus pandemic effect on the Turkish economy. Chapter 5 is the methodology which analyzes the data of targeted variables statistically by using the E-views software. It contains detailed description of the study's methodology with the model to be tested and addressed in equations using symbols representing the dependent variable along with the independent variables. It contains scatter diagrams showing the relationships presented mathematically. Moreover, the chapter consists of equations in which each independent variable is replaced with its numerical value. At the end of chapter 5 there will be an econometrical for each part of the thesis. Finally, chapter 6 will be a final conclusion and, limitations of the study, future research suggestions, and managerial implications and recommendations that might be addressed to the competent authorities for better economies.

CHAPTER 2

LITERATURE REVIEW

There are tremendous considerations that place a spot on the relationship among macroeconomic aggregates and oil price fluctuations. Oil price's impact on variables such as inflation, economic growth, and exchange rate have been in the center of most studies. The proposal consists of two parts, the first of which calls for a thorough analysis of the relationship between crude oil prices and Turkey's economic data. The second is focused on how the energy and stock markets are related, as well as how susceptible the coronavirus pandemic is. The impact of crude oil prices on economies is mainly determined whether the country is an importer or an exporter of crude oil. That is why in the thesis, the literature is divided into two parts; oil importing countries and oil exporting countries.

2.1. Oil Importing Countries

The impact of oil price shocks on economic activity in oil importing countries have been studied more extensively in the literature than the impact of oil price shocks on economic activity in oil exporting countries. A common conclusion of many economists referred to in this section is that higher oil prices are negatively correlated with subsequent recessions in oil importing countries. When oil prices rise, increase in production costs will follow and companies tend to reduce output. Similarly, reducing oil prices lowers production costs and price levels. However, in terms of price maintenance, the product cost does not go down as the manufacturers maintain high prices. Several empirical studies have examined the impact of oil price shocks on inflation.

In the first line of study, due to the scarcity of oil supplies, Turkey faces a high current account deficit. Energy imports thus add the most to the current account deficit. Thus, oil price increase is projected to minimize imports. By analyzing the monthly data between 2006 and 2018, Kilcia (2019) resolved the causal relationship between crude oil prices and energy imports. The findings showed that there is a unidirectional causality between Brent crude oil price and the import of energy in Turkey during the time of study. Husaini and Lean (2021) investigated the asymmetric effects of the oil price and the currency rate on inflation rate. An increase in the price of oil has a higher influence on the PPI

than it does on the CPI were explored. Therefore, a rise in the exchange rate has a considerable impact on both the CPI and PPI. The researchers advised policymakers to keep their energy incentive schemes going and suggested that monetary policy may be strengthened and made more efficient for price stability.

Al Rasasi and Yilmaz (2016) examined quarterly observations between 1987 and 2015 about the impact of oil prices on the economic growth of Turkey. The paper employed some macroeconomic factors such as GDP, CPI, nominal exchange rate, and crude oil price (WTI). The researchers relied on two types of econometric models. The Benchmark Model which is represented by a VAR model is the standard system looking at the results of oil price shocks on different macroeconomic and monetary factors. On the other hand, the Threshold Model aims to analyze how the Turkish economy reacts to increasing and decreasing oil prices. The study found proof of significance that part of oil price fluctuations affects macroeconomic variables that influence economic growth. In addition, high oil prices are found to be positively correlated with high inflation, and negatively correlated with the exchange rate (Al Rasasi and Yilmaz, 2016).

Akçelik and Ogünç (2016) explored oil price change rate impacts on residential costs at diverse levels of supply chain in Turkey. The study applied VAR model to analyze the data. First, the paper concluded that the crude oil price was estimated to have one third shares of the retail price. Second, it is estimated that the oil prices have had a long run effect on transport services comparatively to other domestic prices. Overall, Akçelik and Ogünç (2016) gave proof of the influence of oil price on consumer inflation, which could introduce the reasons of high demands on natural gas in the economy.

Oil supply shocks lead to significant reduction in production, which causes negative growth through collapsing commodity exports and expanding unemployment. Çulha, Özmen, Yılmaz (2015) stressed the effect of the sharp drop in oil prices observed on Turkey's commodity export rates. At first, the researchers examined the effect of oil prices on the economic growth of Turkey's trading partners; it was clear that the influence of oil prices on the growth of different groups of countries was in every aspect, different. Although, they investigate that the income elasticity of exports of Turkey was approximately lower than that of other countries that imported oil. The income elasticity of export for

Turkey is less than the other countries, which depends on the current export share of each country.

Bhattacharjee (2013) articulates the effect of the price of crude oil on the Indian economy's whole price index. Moreover, the investigator examined the causality among the rate of change in crude oil prices with inflation and GDP growth. The author used secondary data that was collected in 2010/11 from primary reports and publications. The study found that the price of crude oil plays a critical role in raising the WPI index, which is significant in Karl Pearson's model of declining GDP growth for the Indian economy.

Eryigit (2012) used weekly data from 2005 to 2008 to study the effects of oil price fluctuations and found that oil price had a significant impact on the stock market. However, crude oil prices had detrimental effects on interest rates and exchange rates. Gökçe (2013) investigated the energetic impacts of crude oil instability shocks on the economic development of Turkey through estimation of a VAR model. Generally speaking, the study suggested that the comprehensive impact on economic booming was caused by crude oil price in the long run.

Researchers rarely concentrate on the causal relationship between the price of oil and macroeconomic aggregates following the oil price crisis of 1973. Gökmenoğlu, Azin, and Taspınar (2015) analyzed the effect on inflation, GDP and industrial output of the volatile oil price shocks. For Turkey, the research covered the period from 1961 to 2012. Three separate measures consist of the methodology of the study; unit root, cointegration and causality test. Gökmenoğlu, et al. (2015) concluded that Phillips-Perron (PP) proposed that all variables are integrated of order one. Moreover, the Johansen cointegration test had predicted a long-term association. Last but not least, the Granger causality test tested a unidirectional relationship that extends from the price of oil to industrial output.

Çelik and Akgül (2011) have revealed that the raise in widespread crude oil prices had an inflationary impact in Turkey's economy. In their study, the relationship between CPI and crude oil price was inspected monthly from 2005 to 2010 through applying VECM Model. According to their findings a 1% increase in oil prices has risen CPI by 1.26%. Besides, change in crude oil prices was found to be unidirectional through applying Granger casualty test for changes within CPI.

The fluctuations in oil price in Turkey's province had been explored by (Aktaş, Özenç, and Arıca, 2010). Time series data covers the years from 1991 throughout 2008, by analyzing macroeconomic variables such as unemployment, GNP, inflation, and export/import ratio. The methodology of the study is VAR model, which deduced a negative relationship of oil price with export/import ratio and unemployment is observed, and a positive correlation between oil prices and inflation is found. On average, the study showed stability in the interconnection between crude oil prices and the variables under study via applying impulse-response analysis (Aktaş et al., 2010).

Çatık and Önder (2013) studied the oil price fluctuations' negative effects on total industrial production index in Turkey for the period between Jan/1988 and March/2011. They found that, when oil price changes exceed a certain limit, they have a significant effect on inflation and productivity. In the low oil price change regime, macroeconomic variables have a reduced sensitivity to oil price shocks, resulting in a decrease in economic activity.

Köse and Emre (2021) used monthly data from March 1988 to August 2019 to study the impact of oil price volatility on inflation in Turkey by using a SVAR model. The impacts of oil price volatility on inflation and labor cost were modest in 1988 as estimated by the variance decomposition, but escalated later years. The reason for inflation in the latest half of the period was from exchange rate. According to the results of impulse response functions, the effect of inflation on oil price and currency rate were depicted in early period of study. After a few months, inflation began to respond to labor costs in a substantial way. The findings of this study show that to reach for price stability the government should apply monetary and fiscal policies (Köse and Emre, 2021).

Crude oil is priced in US dollars across the world; thus, fluctuations in oil prices have a different impact on country exchange rates in the long run (Göcekli and Peker, 2015). An increase in oil price causes appreciation in currency rate for oil-exporters and depreciation for oil-importers. The link between the price of crude oil and the dollar exchange rate in Turkey was examined using monthly data from 2003 to 2014 by Göcekli and Peker (2015). In future, global oil prices are expected to soar to roughly \$185 per barrel, while GDP loss caused by 121 percent (Aydin and Acar, 2011). However, a fixed

exchange rate system can result in cumulative inflation of roughly 5% as assessed by the CPI index according to this research.

According to the findings of Geng, Qiang, and Fan (2016), the region's natural gas import prices have significantly improved over the long run as a result of both international oil prices and worldwide financial growth. The shock's effects are least severe in North America and Europe, and most severe in Asia, with regional pricing schemes playing a major role. Kırca (2020) examined the correlation between the oil-gas price index and Turkey's economic development by applying VAR on quarterly data from 1998-2019. Kırca (2020) is the first research to look at the link between Turkey's oil-gas price index and GDP, which is permanent for five periods and negative according to the research.

2.2. Oil Producing (Exporting) Countries

In comparison, the other part of the related literature shows the effect on oil-exporting countries of oil price shocks. There is a clear connection between the rise in oil prices and higher economic activity in oil-exporting countries, based on previous literature. Cherp et al. (2014) tested the market factors, stability of price, and technology substitution to estimate the model of US besides that of China and stands with a total contrast in price control. While price control perfectly prohibiting oil price shocks from diffusion in the domestic price in the short run period, the opposite was in the US situation. Farzanegan and Markwardt (2009). had shown that crude oil price changes affect inflation positively both in the short term and in the long term in Iran. However, using the same study had been done by Davari and Kamalian (2018) which concluded an opposite result from the previous mentioned authors. But in the same time the analysis revealed a significant impact between the decrease in oil prices and inflation. Moreover, a study that oil prices and inflation are a positively related were also confirmed by Wu, Lib, and Zhang (2013) for the US economy which was done for the period between 1995 and 2005. The authors discussed oil prices, inflation, and interest rates, focusing on potential monetary policy reactions to external shocks.

For Azerbaijan case Mukhtarov, Mammadov, and Ahmadov (2019) examined the correlation among inflation, oil price and exchange rate cover the period from 1995 to

2017. VECM estimations assessed a coordinate significant relationship from oil prices and exchange rate to inflation within the long-run. It can be deduced that 1% change in oil price will increase exchange rate by 0.58% and inflation rate by 1.81%, separately. In brief, Mukhtarov et al. (2019) discovered that inflation had been affected during all erratic oil price fluctuations. Furthermore, the exchange rate acts as an intermediate among oil prices and inflation.

Akhmedov (2018) investigated oil price shocks for both oil exporting and importing countries. The objective of his inquiry was to create a contingency plan to help government institutions of Kazakhstan to handle crude oil fluctuations. Akhmedov (2018) arranged an econometrical model and created scenarios by considering three oil price scenarios using VAR model. The study concluded that the Kazakh government is ought to focus on oil price stability in the long run as the main aim in controlling the nation's future economic activity. Ftiti, Guesmi, Teulon, and Chouachi (2015) covered the period from September 2000 to December 2010 by using the evolutionary co-spectral theory of Tong and Priestley (1973). In addition, the researchers used granger cointegration test which showed a time-varying relationship as short and medium-run among the prices of oil and economic growth within the OPEC countries in erratic periods.

The demand for crude oil has been faced by a reduction that led to the international oil price to fall continuously. Offiong, Atsu, Ajuade, and Ibor (2016) examined the uncertainty on the economic growth of Nigeria to explore that worldwide oil price shocks influence the State's economy, contrarily to all other cases. Moreover, the effect of instability in oil prices on economic growth of Libya examined by Nagmi and Aimer (2016) by applying VAR model and cointegration tests for 15 years from 2000 until 2015. Relatively speaking, the findings showed that both factors are integrated of order one. In brief, the results discovered that higher oil price contains a coordinate influence on the economic growth of Libya in the long run.

Further studies on Nigeria one of the OPEC countries by Ogboru, Rivi, and Idisiet (2015) who examined the effect of crude oil price changes on the economic development. Times series data had been analyzed for the period between 1986 and 2015. In the paper real effective exchange rate, inflation rate, crude oil price, and GDP growth rate are used

as indicator terms. Long-term effects of inflation and exchange rates were notably negative, where a positive and unidirectional relationship between crude oil prices and GDP growth rates was found (Ogboru et al., 2015).

Ghalayini (2011) assessed that there was a negative correlation between oil prices and economic growth among oil importing countries. However, it is positive for oil exporting countries. The data used in this article covers OPEC countries besides Russia, China and India. The paper has applied Granger causality tests which concluded that there is no proof for the responses between oil price changes and economic growth for many countries. However, the results showed a unidirectional relationship from oil price to GDP for the OPEC countries.

The impact of oil price shocks on the output growth of selected MENA countries, which are considered to be net exporters or net importers, regardless of their negligible impact on oil prices, has been examined by (Berument, Ceylan, and Dogan, 2010). The economic accomplishment of the states was not influenced by the world oil price shocks. The study applied VAR model, which is based on inflation, real exchange rate, and output growth for each country from 1952 to 2005. On the one hand, the estimations showed that oil price booms have a statistically positive impact on the outputs of Oman, Iran, the United Arab Emirates, Iraq, Qatar, Kuwait, Algeria, Libya, and Syria. On the other hand, crude oil price fluctuations did not disclose any statistical considerable beams on the other countries economic growth.

Moreover, Mekhelif and Agon (2018) studied the reflection of fluctuations in oil prices on economic growth in Algeria during the period (1986-2017), using the VECM model. The Algerian economy has been found to be a revenue-generating economy that relies on fuel revenues to fund its production, making economic growth rates heavily influenced by changes in oil prices. Ewing and Thompson (2007) explored how crude oil prices are correlated to output, consumer prices, unemployment, and stock prices over time. The findings imply that crude oil prices are pro-cyclical with the lag industrial production indicator.

However, Khan, A., Khan, M., and Khan, A. (2020) studied the industrial production in the medium term, and investigated that crude oil has a positive demand and natural

gas has a negative supply relationship with industrial production indicator. Natural gas, crude oil, and industrial production have an unbalanced connection in the long run. It is advised that a combination of conventional and non-conventional energy resources be used in an energy policy (Khan et al., 2020).

Panagiotidis and Rutledge (2007) looked at the link between UK wholesale gas prices and Brent oil prices from 1996 to 2003. As traditional gas market liberalization theory indicates, oil and gas prices decoupled during this time. The researchers found a long-term equilibrium relationship between natural gas and oil prices in the UK. These results do not support the theory that the price of gasoline and oil should decouple. Table 1 is a comprehensive review for oil exporting post literatures.

Table 1

Overview of Comparable Scientific Literature of Oil exporting Nations

Researcher	Observation	State	Model	Results
Wu et al. (2013)	M1995-2005	U.S.	ARDL	↑Oil Price↔Inflation↑
Cherp et al. (2014)	M2003-2013	Iran	ECM	↑Oil Price↔Inflation↑
Kazakova and Polbin (2015)	A1980-2011	Russia	PANEL	↑Oil Price→ ↓Inflation
Farzanegan et al. (2009)	Q2003-2008	Iran	ARDL	↑Oil Price≠Inflation ↓Oil Price→ Inflation↓
Yotzov, Djankov, Nguyen, and Arezki (2020).	A1995-2018	Algeria, Angola, Libya, Nigeria	ARDL	↑Oil Price→ Inflation↑

Ewing and Thompson (2007)	Jan/1982-Nov/2005	USA	Hodrick–Prescott Analysis	$\uparrow$ Oil Price $\rightarrow$ CPI $\uparrow$ $\uparrow$ Oil Price $\rightarrow$ X (IPI) $\downarrow$
Khan et al. (2020)	1986-2018	USA	Quantile Regression	$\uparrow$ Oil Price $\rightarrow$ IPI $\uparrow$ $\uparrow$ Natural Gas Price $\rightarrow$ IPI $\downarrow$
Panagiotidis and Rutledge (2007)	1996-2003	UK	VAR	$\uparrow$ Oil Price $\rightarrow$ Natural Gas Price $\uparrow$ in Long-Run
Geng et al (2016)	Jan/1997-Aug/2011	USA Asia Europe	VAR	$\uparrow$ Oil Price $\rightarrow$ Natural Gas Import Price $\uparrow$ $\uparrow$ Oil Price $\rightarrow$ Output $\uparrow$ in Long Run

Moreover, as shown in Table 2, there is a comprehensive review for oil importing post literatures

Table 2

Overview of Comparable Scientific Literature of Oil Importing Nations

Researcher	Observation	State	Model	Results
Eryigit (2012)	W2005-2008	Turkey	VAR	$\uparrow$ Oil price $\rightarrow$ stock market $\uparrow$ $\uparrow$ Oil price $\rightarrow$ interest rate $\downarrow$ $\uparrow$ Oil price $\rightarrow$ EX rate $\downarrow$
AL Rasasi and Yilmaz (2016)	Q1987-2015	Turkey	SVEC	$\uparrow$ Oil price $\rightarrow$ inflation $\uparrow$

Ftiti, Tiwari, and Fatnassi (2014)	A1990-2013	India	ARDL	↑Oil price→ inflation↑in long run
Bhattacharjee (2013)	M2010-2011	India	Karl Pearson	↑Oil price→ WPI ↑ ↑Oil price→ GDP growth↓ ↑Oil price→ GDP per capita↓
Gershon et al. (2019)	A1980-2015	South Africa	VAR	↑Oil price→ energy consump- tion↓
Husaini and Lean (2021)	1978-2018	Indonesia Malaysia Thailand	NARDL	↑Oil price→ CPI↑ ↑EX→ CPI↑
Köse and Emre (2021)	March/1988- Aug/2019	Turkey	SVAR	↑Oil price→ CPI↑ ↑EX→ CPI↑ long-run
Göcekli and Peker (2015)	Monthly (2003/- 2014)	Turkey	ECM	↑Oil price↔EX of dollar↓ (depreciation) in long-run
Aydin and Acar (2011)	Daily-2004	Turkey	GEM-D	↑Oil price→ inflation↑ ↑Oil price→ GDP↓
Kırca (2020)	1998Q1-2019Q4	Turkey	VAR	↑Oil price→ GDP↓in long-run

2.3 Literatures Related to Coronavirus Pandemic Issue

Throughout history, the humanity has struggled with global pandemics many times. There are around twenty recorded major pandemics that each resulted in the death of more than 1 million people. The deadliest of all was the Black Death (Caused by Bubonic Plague) occurred in the mid-14th century, mostly affected the European population and killed between 50 and 200 million people around the world. Black Death was followed by Spanish Flu, which occurred between 1918 and 1920 and killed 50 million people. Between the 19th and the 20th centuries, there were seven outbreaks of Cholera epidemic. They claimed between 50 and 100 million lives. In the late 1950s and 1960s, two influenza pandemics, Asia Flu and Hong Kong Flu, resulted in the death of 1 to 4 million people around the

world (Gonzalez and Martin, 2021)¹. Finally, there are two prevailing global pandemics, HIV/AIDS and COVID-19. HIV/AIDS have claimed more than 36 million lives since 1981 and COVID-19 claimed between 5 to 10 million since 2020. According to Gonzalez and Martin (2021), most of these pandemics spread through commercial routes. In other words, global commercialization was the main cause of the spread of these diseases. For additional causes of the spread of these pandemics, see Saker, Lee, Gilmore, and Campbell-Lendrum (2004). During their effective periods it has been noted that the tax revenues fell significantly, labor became relatively inefficient and crops decreased. In major cities curfew was forced. Although there were many pandemics, which resulted in more death than the COVID-19, none of them had affected the global economy as bad as the COVID-19. Because of their socioeconomic and political consequences, these viruses were labeled as worldwide pandemics at the time. Closed borders, curfews in major cities, shut down supply lines, and cancelled or postponed historically important events throughout the world are not among humanity's experiences in the previous century. An invisible and tiny insect nearly shuts down the world's economies and puts a stop to human activity and civilization.

Due to the coronavirus pandemic in the world which broke out in the beginning of 2020, there was a steep decrease in crude oil prices, which was a rare situation. Within the second line of research, the thesis will review some cases that had faced decreases in oil prices that maybe similar to the coronavirus crisis in affecting crude oil price and the world economy. The pandemic of Coronavirus (COVID-19) originated in Wuhan, where the first case of infection was reported on December 31, 2019. As introduced by (WHO, 2020) on January 21, 2020, the disclosure of the premier coronavirus came after 49 days. COVID-19 leads to uncertainty throughout the entire global economy and influences the instability of monetary markets which detected in March 09, 2020. Saudi Arabia exploded the market with oil that led to the reduction in general oil prices with a registered slump of about 20% in one single day.

¹ For a detailed historical review of global pandemics, see Gonzalez and Martin, 2021.

Owing to this pandemic, Albulescu (2020b) outlined the negative effect of COVID-19 daily death numbers on crude oil prices in the long run, whereas holding monetary instability and the US financial approach vulnerability consistent. Açıkgöz and Günay (2020) examined the imperative responses of the long-term world economic factors to the pandemic in economic sectors by assessing their prices concurring to the information detailed for both the world and Turkey. Additionally, the analysts connected four economic and political scenarios for the past pandemics. The paper used analytical methodology by reviewing the papers and dialogs about the economic characteristics of this public issue, and helps to form a few studies in thought. Overall, the study concluded that this pandemic has tremendous negative impacts on employees, clients, supply chains and monetary markets. To summarize, it is predicted to cause a global economic recession.

Furthermore, as of the pandemic ending period is uncertain, the estimations showed unpredictable length and scale of this contraction (Açıkgöz and Günay, 2020). Generally speaking, the article showed that the world economy needs a long period to recapture from the permanent pandemic shift within the world and its legislative issues on wellbeing, security, trade, farming, and industrial production.

WHO (2020) reported many cases of people worldwide which had been infected by viruses as immunodeficiency virus which known as AIDS disease. Bloom and Mahal (1995) studied the effect of AIDS infection on the economic growth. The data of the study had been collected from fifty-one developing and industrial countries. The authors used AIDS rate as the independent variable and GDP per capita percentage rate as the dependent factor. Moreover, the methodology of the study used a well-established growth model to control on other variables that maybe correlated with AIDS variable and had an effect on GDP growth. To summarize, the paper found that AIDS had insignificant effect on per capita income.

Aydın and Ari (2020) examined the effect of falling oil prices for the impact of COVID-19 on Turkey's tourism, travel and transportation sectors. The study's key point is that falling oil prices will lead to compensation for the loss of tourism, travel and transport revenue. Results indicate that COVID-19 lowers GDP by 1.16, but declining oil prices

offset this decline by 0.72 percent increases in GDP. Imports could provide a new solution for overcoming non-recoverable results.

Furthermore, it is projected that this global pandemic could lead to economic production losses of around trillions of dollars (McKibbin and Fernando, 2020). They investigated the effects of COVID-19 on the economy and found the global loss of GDP to be between 283-917 billion dollars. As a developing world, Turkey faces similar difficulties in coping with the economic and social recovery of other nations. GDP loss from this outbreak could fluctuate in the Turkish economy from 3 to 130 billion USD. This study, however, covers 20 countries and four regions using the G-cubed model to forecast, based on global results of the effects of COVID-19.

For the data from January 22 to March 30, 2020 Mzoughi, Urom, Uddin, and Guesmi (2020) used an unrestricted VAR model to examine the impact of COVID-19 pandemic on crude oil prices, CO₂ emissions, and stock market volatility. The study demonstrated that the detrimental impact of the growth in COVID-19 infections results in a short-term decline in crude oil prices. Other indication of the forecast study is that the response of CO₂ emissions to COVID-19 infection shock was negative, which is the only one positive effect for this pandemic until now. The study also compares the error variance in CO₂ emissions levels to those in the stock and energy markets, which exhibit a larger value than the others.

Özkan (2020) analyzed the monthly volatility of 23 sector indexes traded on Borsa Istanbul from June 2019 to July 2020, which revealed that COVID-19 caused all sector indexes to experience an increase in volatility in March 2020, when cases in Turkey initially arose and quickly expanded; The stocks of sports enterprises saw the largest volatility jump during COVID-19, whilst the stocks of insurance companies saw the smallest volatility jump. After March 2020, realized volatility prices for all business indexes will return to normal. The uncertainty caused by COVID-19 on the Turkish stock market has disappeared. These results are supported by the volatility metric of GARCH-based volatility (Özkan, 2020).

Alber and Saleh (2020) looked at the impact of COVID-19 global spread on the capital markets of Gulf Cooperation Council (GCC) countries. Cumulative cases, recent

cases, cumulative deaths, and new deaths have also been used to monitor the transmission of the Coronavirus. The distribution of the Coronavirus has been calculated in terms of numbers per million of population, while stock market return has been measured in terms of stock market index. The majority of paper on this subject examined Coronavirus dissemination in heavily infected countries, with an emphasis on developing capital markets. They tried to figure out how the financial markets in the GCC reacted to the COVID-19 spread. Over the study era, there were major variations in stock market indexes, according to the findings. Furthermore, financial market returns seem to be affected by new Coronavirus deaths. Besides that, this has been verified for the month of March, with no proof of these implications for the months of April and May 2020 (Alber and Saleh, 2020).

Sarı and Kartal (2020) investigated the factors that influenced Turkey's main stock exchange index changes during the COVID-19 era. In this case, random forest and help vector machine algorithms are used to test 14 variables including national country and market levels using daily data between Jan 1, 2019 and May 15, 2020, which covers the period before and after pandemic. According to Sarı and Kartal (2020) the results show that in the pre-pandemic era, the most relevant variables were “*foreign investor retention, credit default swap spreads, government bond interest rates, Morgan Stanley Capital International (MSCI) emerging markets index, and volatility index*”. Furthermore, as the MSCI emerging markets index in the stock sector changes, the value of variables changes.

Another study for Kartal (2021) investigated how local currency oil prices responded to COVID-19 epidemic studying pre and pandemic periods (July 25, 2019 to October 30, 2020). Foreign exchange (USD-TRY), credit default swap spread, global uncertainty, and global volatility are used as control variables in a multivariate adaptive regression model. Kartal (2021) revealed that the volatility index has the greatest impact on oil prices; and the COVID-19 epidemic has an impact on local currency and oil prices in Turkey.

Moreover, Sercan et al. (2020) explored another type of results which appeared a positive effects of COVID-19 on financial markets and commodity markets. They studied the daily observations between 22 Jan 2020 and 20 Apr 2020 by applying ARDL model. The potential effect of COVID-19 active cases was tested on gold prices, oil prices and

VIX Index variables. The results showed a significant relationship among coronavirus infected numbers, gold price, and VIX index. However, the analysis introduced a no cointegration between oil price and active cases (Sercan et al., 2020). Additionally, Yan (2020) looks at how Chinese financial markets respond to COVID-19 outbreaks over a fifty-day period, from January 20 to April 7, 2020. The findings suggested that coronavirus causes large price swings in stocks. Stock prices drop sharply in tandem with Wuhan's quarantine, but Yan (2020) found that stock returns reverse every ten trading days during the studied interval.

Kılıç (2020) illustrated that while the outbreak has had a largely negative impact, the pandemic has had a positive impact on some markets. Using the event study process, the impact of coronavirus on Borsa Istanbul sector returns was investigated. Many of the indexes had negative irregular returns, according to the study. However, the tourism and manufacturing industries have the highest negative returns, while the trade industry has the highest positive returns. Öztürk et al. (2020) investigated the uncertainty brought by coronavirus pandemic on Turkey by examining Borsa Istanbul stock market. The researchers used daily data for sectors of stock market and analyze these data by a fixed effect model. The researchers compared sector indexes of Turkey with indexes of Europe and the global; the results show a high effect on Turkey than other countries. Other results showed that industry, sport, banking sectors are the most infected with this crisis. However, the least infected sectors where food and real state.

Kayral and Tandoğan (2020) examined the impact of COVID-19 on the returns of BIST-100 index, gold, and exchange rates of dollar and euro by estimating GARCH model during 2015 and 2020. The results showed that BIST-100 and gold were affected by the first lag of COVID-19. However, this indicates a temporary effect and the trend returns back to increase. Another important result is that the higher infected cases lead to high volatility in stock market, specially, a high volatility from dollar to euro and the opposite. On the other hand, Kılıç (2020) illustrated that while the outbreak has had a largely negative impact on BIST-100, the pandemic has had a positive impact on some markets such as trade industry.

Song, Bouri, Ghosh, and Kanjilal (2020) found that COVID-19 has positive effects on stock index and negative effects on oil price in the short run. However, Zhang (2020) investigated the opposite relationship between stock price and COVID-19 in short run period. Another study done by Jareño, González, López, Ramos (2021) showed that the effects of the pandemic on oil price shocks have important impacts on increasing cryptocurrency returns in short and long run periods. Thai-Ha Le, Anh Tu Le, and Ha-Chi Le (2020) and Ruchuan Ma et al. (2020) examined WTI (West Texas Intermediate) oil prices and found out that they were affected negatively by COVID-19. Abuzayed and Al-Fayoumi (2020), Bourghelle, Jawadi, and Rozin (2020), Zhang (2020), and Xu (2020) examined the volatility of oil and stock prices in the short and long run period of the pandemic. Except for Zhang (2020) study, which looks at a high volatility of both oil and stock markets over the long term, the results of all studies revealed significant volatility in oil prices and moderate volatility in the stock market. As shown in Table 3, COVID-19 affected stock and energy markets in the long run and short run as estimated in previous studies.

Table 3

Overview of Comparable Scientific Literature of COVID-19 Outbreak

Researcher	Observation	State	Model	Results
Albulescu (2020a)	Jan21– March9/2020	USA	ARDL	↑ COVID19 → oil price ↓ long run
Aydın and Ari (2020)	Jan/2020– March/2020	Turkey	CGE	↑ COVID19 → oil price ↓ oil price ↓ → GDP ↑
McKibbin and Fer- nando (2020)	Jan/2020– March/2020	Global Turkey	CGE	↑ COVID19 → GDP ↓

Mzoughi et al (2020)	Jan/22-Mar/30/2020	Global	VAR	↑ COVID19 → oil price ↓ short run ↑ COVID – 19 → VIX ↑
Sercan et al. (2020)	22/Jan-20/Apr/2020	Global	ARDL	↑ COVID – 19 → VIX ↑ ↑ COVID19 → oil price ↓ short run
Özkan (2020)	June 2019 - July 2020	Turkey	GARCH	↑ COVID19 → BIST ↓ short run
Sarı and Kartal (2020)	01.02-05.15.2020	Turkey		↑ COVID19 → VIX ↑
Yan (2020)	January 20-April 7, 2020	China	VAR	↑ COVID19 → stock price ↓
Öztürk et al. (2020)	January - April/2020	Turkey Europe Global	Fixed effect model	↑ COVID19 → BIST ↓
Kayral and Tandoğan (2020)	2015- 2020	Turkey	GARCH	↑ COVID19 → BIST100 ↓ ↑ COVID19 → gold price ↓ short run ↑ COVID19 → VIX ↑
Song et al. (2020)	Sep 21, 2010-Aug 28, 2020	Global	TVP-VAR	↑ COVID19 → stock index ↑ → crude oil price ↓ short run
Jareño et al. (2021)	Nov 20, 2018-June 30, 2020	Global	NARDL	↑ COVID19 → oil price ↓ → crepto returns ↑

Thai-Ha Le et al. (2020)	17 Jan - 14 Sep, 2020	Global	ARDL	↑ COVID19 → VIX ↑ → WTI price ↓
Jia et al. (2020)	March/April 2020	China	CGE	↑ COVID19 → oil price ↓ oil price ↓ → GDP ↑
Abuzayed and Al-Fayoumi (2020)	Jan 2017-May 2020	GCC	DCC-GARCH	COVID19 ↑ → oil price ↑ → volatility of stock market ↓
Ruchuan et al. (2020)	10 March-9 April 2020	Global	Event study method	↑ COVID19 → oil price ↓
Bourghelle et al. (2020)	2 Jan 2014 - 1 April 2020	Global	VAR	COVID19 ↑ → WTI price ↑ oil demand ↓ and oil supply ↑ ↑ COVID19 → oil price ↓ short run
Zhang (2020)	4 Jan 2006-31 Aug 2020	US-Japan-Germany	VAR	↑ COVID19 → stock price ↓ short run COVID19 ↑ → vol. of oil/ stock ↑ long run
Xu (2020)	Jan 2018-April 30 2020	Canada	Time varying RE-GARCH	Before 20 March COVID19 ↑ → VIX ↑ After 20 March COVID19 ↑ → VIX ↓
Atri, Kouki, and Gallali (2020)	Jan 23 -June 23 2020	Global	ARDL	COVID19 news ↑ → gold price ↑ COVID19 news ↑ → oil price ↓
John and Li (2020)	Feb -April 2020	Global	Equilibrium Model	COVID19 ↑ → VIX index ↑ COVID19 ↑ → market index ↑

Other types of literatures that the thesis should shed a light on, which are about the opportunities that the pandemic can offer to have a better economy in the future. Buheji and Ahmed (2020) illustrated that throughout history, epidemics have offered people many problems, but have also brought many obvious and unknown possibilities with them. The Coronavirus is no exception, and some literatures foresee the possibilities for a better future brought to the economy by this deadly crisis. These studies reviewed the numerous opportunities brought to the world by this virus and related recent events, such as SARS. This paper created new directions toward more inspiring economies that would fix the key elements in the journey of the global economic growth. Buheji and Ahmed (2020) suggested method for taking advantage of the possibilities of such a dynamic crisis while mitigating its risks. If we want to see solutions which could save humanity from the coming crisis, further studies are strongly recommended.

In Chapter 2, previous researches about the impact of the shocks in the price of crude oil on economic variables such as CPI, exchange rate, GDP, total industrial productions index, oil imports, and other microeconomic and macroeconomic indicators for Turkey and other countries' experiences was thoroughly reviewed. Moreover, the chapter discussed researches about COVID-19 crisis and its effect on stock and energy markets, and other papers who studied the pandemic positive effects for better future. Chapter 3 will present an explanation for the targeted economic indicators and how significantly they affected each other. Additionally, a thorough analysis of the impact of the oil market on Turkey's economic growth as an oil-importing nation will be conducted.

CHAPTER 3

DESCRIPTION OF CRUDE OIL AND ECONOMIC INDICATORS OF TURKEY

Economic development incorporates a vital part in industrial advancement, as of the primary erratic oil price shocks in 1973. Financial specialists look at the highlights of oil price fluctuations on the inclusive economies, since oil has been an essential asset for industrial businesses. This chapter will clarify changes in oil price in two ways. First, a factual outline will be presented around the essential relationships through analyzing the authentic information. Second, going back to economic speculations related to how oil price shocks ought to carry on over time.

3.1 Crude Oil Price Indicator

Crude oil had two types which are West Texas Intermediate (WTI) and Brent oil that are measured by barrels. While the OPEC barrel price is used as a method of pricing. Oil can be classified by its weight and ingredients. As a matter of fact, WTI crude oil is the leading quality, which derives its qualities from its lower weight and the substances that donate it. Consequently, crude oil is referred to as "the light and sweet" oil. Because of these qualities, it is effective for producing gasoline, which is regarded as the primary American benchmark for crude oil. The average prediction for WTI is \$5–\$6 per barrel, which is superior to the OPEC basket price.

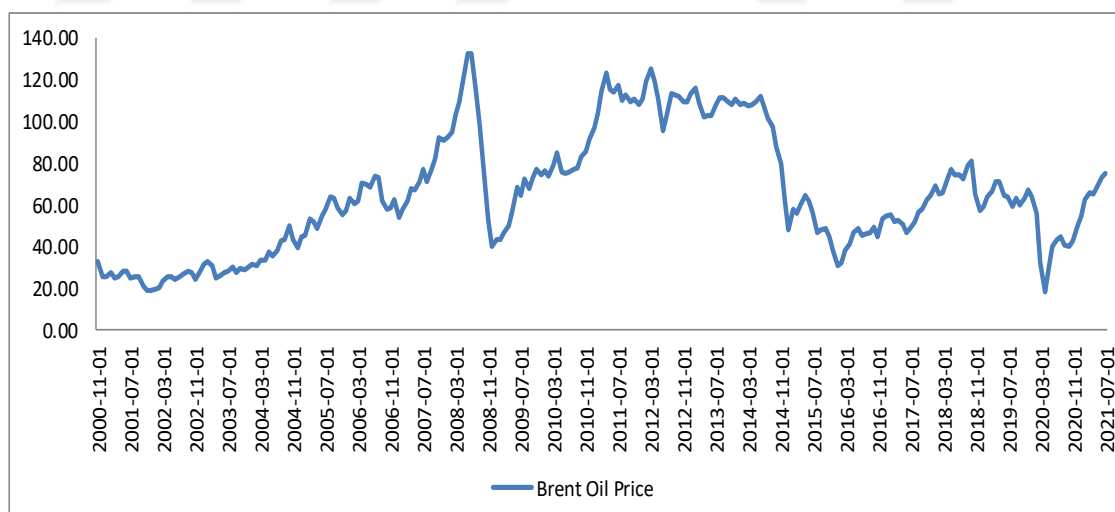
Brent crude oil is extracted from 15 diverse oil wells. The quality of Brent oil is less than WTI, since it is less "light" and "sweet" in spite of its proficiency. For occurrence, prices for other crude oils are estimated by comparison with Brent. Brent oil is priced in different techniques, the primary technique by calculating an ordinary of \$4 per barrel, the second technique by comparing it with the OPEC barrel price. OPEC nations organize the world oil price through the OPEC basket price, which are lower than that of Brent and WTI oils because of their lower quality, relative to the designed substance, which in terms makes them "sour", and less productive for the production of gasoline.

Figure 1 shows the monthly prices of Brent Crude Oil that has been reported by (Federal Reserve Bank of St. Louis, 2021). The graph covers the period between Nov 2000 and July 2021, and the vertical axis indicates the prices of Brent crude oil. From 2000 to

2007, there was a modest rise in the average Brent oil prices. This was followed by a marked increase from approximately 80 to 30 \$ per barrel viewing per day among that year. However, this trend collapsed marginally in financial crisis of year 2008. There was up and down in crude oil prices over the next five years between 2015 and 2020 with a small erratic oil price fluctuations by an average of 60 \$per barrel. Moreover, there is a huge reduction in oil price for year 2020 by approximately 14 \$ per barrel due to corona-virus pandemic crisis. According to Fan and Xu (2011) primary determinants of crude oil price is: Supply-demand basics, product properties of crude oil, crude oil quality, and unexpected political fluctuations. However, there is no agreement among researchers on datum of each of the variables, which particularly causes high instability in oil prices in the long run.

Figure 1

Brent Crude Oil Monthly Price over the period (Nov 2000 – July 2021)



Note. From Federal Reserve Bank of St. Louis (2021). Accessed on Nov, 2021 from <https://fred.stlouisfed.org>

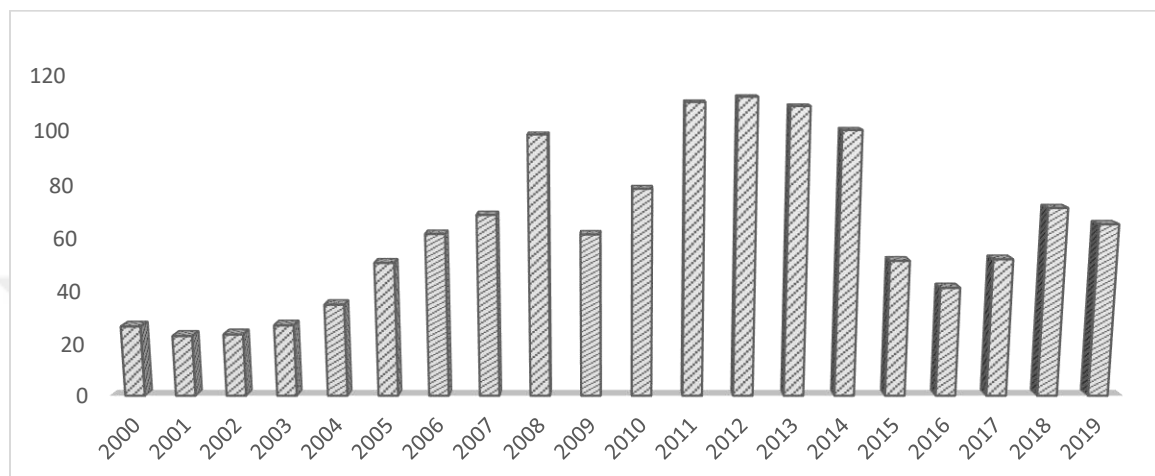
3.1.1 Oil importing and exporting countries situations under crude oil price shocks

Economic position reflects the elasticity of oil price shocks on the economic growth of the countries. Nations are classified as either oil exporting or oil importing to distinguish the impact of oil price fluctuations on the two sorts of nations.

1. *Oil importing countries' situation*

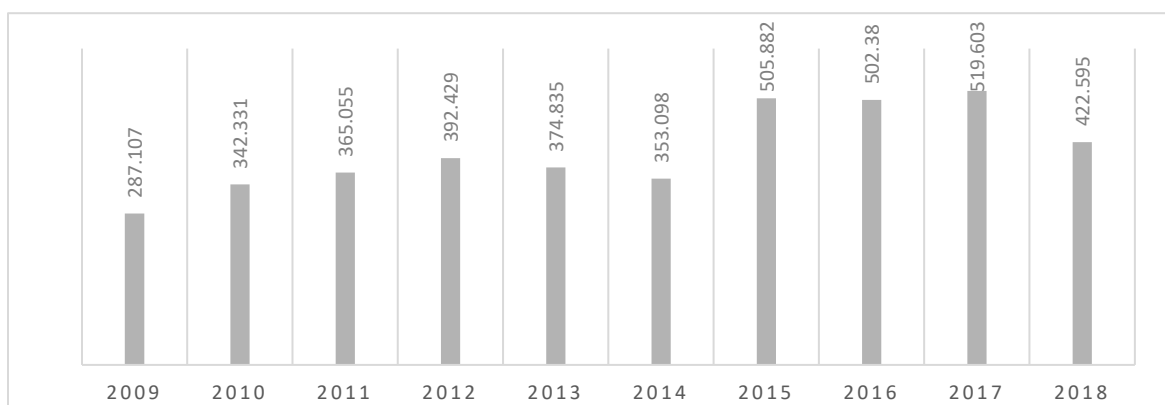
Crude oil price shocks caused many critical modifications on the macroeconomic components of oil importing nations and negatively impact trade. Hypothetical clarifications have displayed a circuitous relationship between variances in oil price and the level of economic development. The shortage of energy can be reflected by oil price variances. Hence, oil price increase not only collapses the economic growth, but also leads to a peak in inflation. The prices of crude oil imports are regulated by IEA Registry of crude oil imports and are driven by supply and demand trends and other determinants as geopolitics. Based on crude oil type, quality, geographical origin, the average prices are calculated by dividing the total cost of procuring by volume as reported for each tariff position by the customs administration. Gross price is registered at the time of importation and include average prices, insurance and freight, but exclude duties on imports. This indicator is calculated on per barrel of oil basis in USD.

Figure 2 shows the yearly crude oil import prices of Turkey (USD/barrel). The graph covers the period between 2000 and 2020; there was a tremendous rise in the average import prices over the eight years. This was followed by a marked increase from approximately 30 USD to 90 USD per barrel/year between 2008 and 2009. Over the next five years, there was a steady level of 110 \$ per barrel for Turkey's oil imports between 2011 and 2014. However, this trend encountered a marginally drop in the following two years. Furthermore, there was another moderate climb between the years of 2016-2018, before experiencing a significant decline in year of 2020 when the coronavirus pandemic was realized.

Figure 2*Crude Oil Import Prices USD/Bar of Turkey (2000-2020)*

Note. From Ychart (2021), accessed on Nov, 2020 from https://ycharts.com/indicators/turkey_crude_oil_imports

In general, latest conditions (2020/2021) in the oil market have a greater effect on oil-importing countries. For energy importing nations like Turkey, world oil prices are extraordinarily critical. It should be well known that crude oil prices increase does not have a positive effect on oil-importing nations as annually data detailed in Figure 3.

Figure 3*Turkey Crude Oil Imports (2009 –2018)*

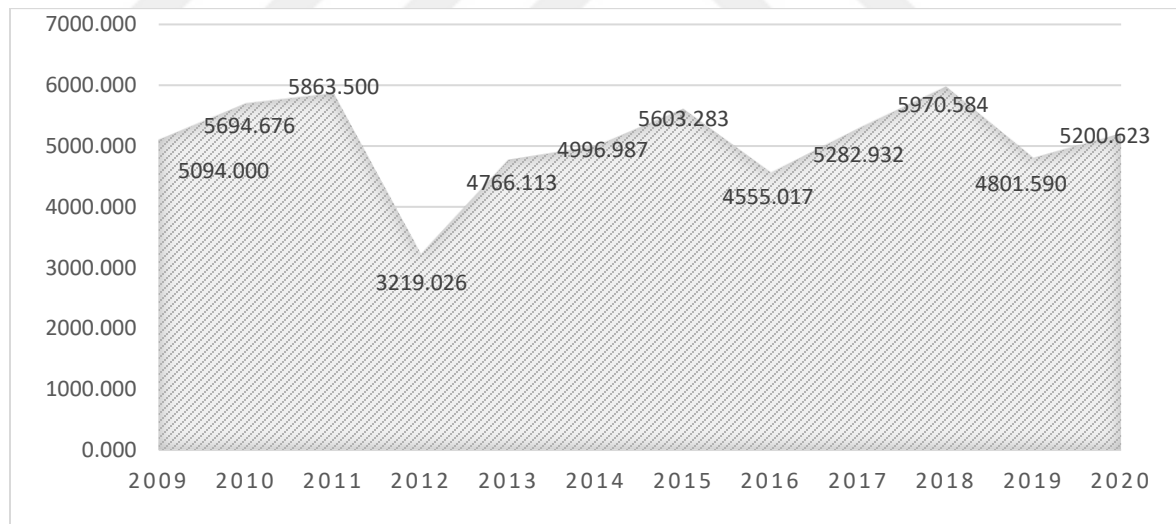
Note. From OECD (2020a). Energy Publications, accessed on March, 2020 from <https://data.oecd.org/energy/crude-oil-import-prices.htm>

2. The situation in oil exporting nations

The sharp rise in oil prices has increased overall global investment and supply for oil exporters. As a result, it will cause the common price level to rise causing inflation. Crude oil price changes have an impact on the exporting country's net exports. The effect of an increase in oil prices caused a peak in net exports in the long run. In recent 2020, WTI benchmark, the key capacity of US crude oil prices, tumbled into negative domains for the first time in history and reached \$37 per barrel. The collapse in oil prices, accompanied by coronavirus pandemic and the Saudi-Russia price war, which negatively affected the world's best oil-exporting nations. Figure 4 shows that oil exports of Turkey were detailed in 2020 at 5,200.6 tons.

Figure 4

Crude Oil Exports of Turkey annually/Ton (2009-2020)



Note. From Energy Market Regulatory Authority, Energy Statistics: Crude Oil: Production, Supply and Trade, accessed on April, 2020 from <https://www.ceicdata.com/en/turkey/energy-statistics-crude-oil-production-supply-and-trade/crude-oil-products-exports-refineries-volume>

For energy exporting countries, the rise in prices simply raises oil production by higher export revenues, despite the fact that a portion of this pick-up would subsequently be counterbalanced by lower export demand, typically due to the economic subsidies suffered by the exchange of accomplices. The danger to these countries is that if prices peak,

GDP growth in exporting countries will decline, reducing crude oil demand and prices. As oil subsidies are discovered and placed on the market, supply rises and costs can be decreased, damaging the development of oil exporting country. High oil prices may also enable industrial countries to manufacture and consume petroleum substitutes more competitively, leading to a decline in crude oil demand.

3.2 Natural Gas Import Price Indicator

Like other source of fossil energies, natural gas is also formed in the deep layers of the earth. There are different compounds in natural gas, such as Methane, natural gas liquids and non-hydrocarbon gases such as carbon dioxide and water vapor. For fuel and making materials and chemicals, natural gas is one of the most commonly used source of fossil energies.

Natural gas consumption in Turkey has increased during this time, decreasing in just four years. By 2017, consumption had reached a peak of 51.6 billion cubic meters, more than double the amount of demand reported in 2005. This has dropped to 43.2 billion cubic meters by 2019. The decline in Russia's share of Turkey's natural gas imports has resulted in higher competition for natural gas prices and an increased share of renewable and local resources in Turkey. Statistics collected by the Turkish Energy Market Regulatory Authority (EMRA) show that Russia's share of imports of Turkish natural gas dropped from 52% in 2017 to 33% in 2019. Turkey imported 45.21 billion cubic meters of natural gas with a 29 percent share of liquefied natural gas (LNG) in 2019. In the first half of 2020, the nation imported the highest volume of gas from Azerbaijan at 5.44 billion cubic meters (BCM). A factor in the growth of imports was the transmission from the Trans-Anatolian Natural Gas Pipeline. In the first half of 2019, Turkey imported 46% less gas from Iran, falling from 3.75 to 2.02 (BCM), with no imports of gas from April to June 2020. In comparison, the consumption of industrial natural gas rose by 3% to 12.4 billion cubic meters (Anadolu Agency, 2019).

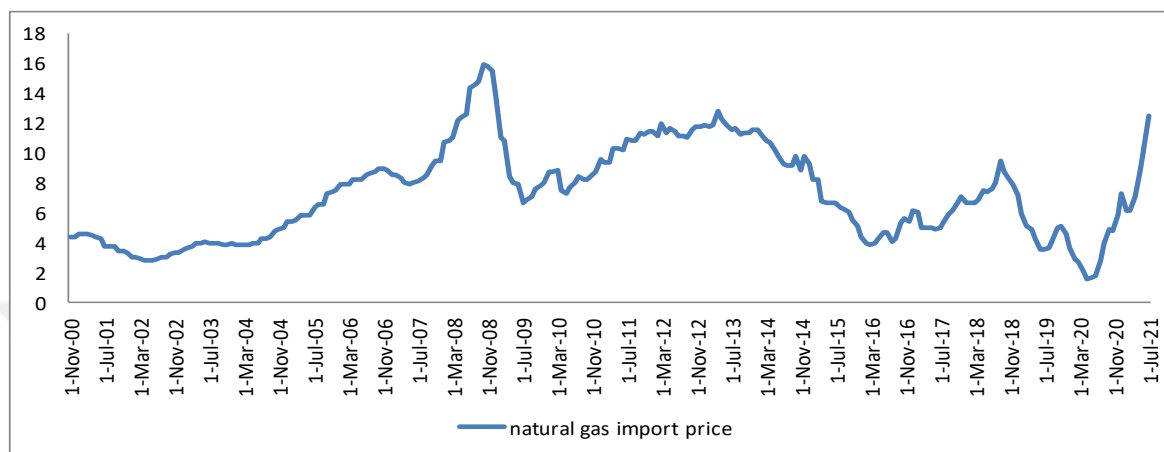
For oil importing countries the effect of oil price increase depends on the supply elasticity of the oil price and the degree to which the market for oil is inelastic in price. Additionally, this relies on how inflation affects rises in oil prices and how much natural

gas import prices are rising as a result of this shock. Other factors influencing crude oil imports from importing countries are the elasticity of natural gas demand in response to changes in the price of crude oil and the impact of higher prices of other types of alternative energy. Customers may turn to other merchandise and services as natural gas at a time when oil prices are increasing and consumers are unable or unwilling to reduce oil consumption, potentially reducing the rate of GDP growth. Usually, the larger the rise in oil prices and the longer higher prices are funded, the greater the macroeconomic effect.

On the other hand, economists translate increasing crude oil prices as inflation in their prices. This may be perceived as prohibitive approaches to moderate economic development. Overly restrictive economic and monetary approaches to contain inflationary weights seem to be followed with recession and unemployment. Expansionary financial and monetary policies however will basically postpone the decline in production expected by increasing oil prices. Moreover, although the economy is suffering from high inflation and unemployment, the rise in oil prices at this stage has the potential to cause extreme damage by reducing the option of economic arrangements over the longer term. Figure 5 shows monthly European natural gas import price for the period of the study Nov 2000 – July 2021. Since Turkish natural gas import price data are not available, European natural gas import prices are taken as a proxy for European market prices.

Figure 5

Turkey Natural Gas Import Price (Jan 2000 – July 2021)



Note. From Ychart (2021), “European natural gas import prices”, accessed on Nov 2021 from https://ycharts.com/indicators/europe_natural_gas_price

The highest natural gas import prices were in 2008, in this year the world was facing a huge financial crisis. In 2008 the federal reserve bank of Chicago declared a recession in US economy as the economic activity index was declined to about 70%. Natural gas production capacity has increased rapidly, and interstate pipeline capacity has been extended to accommodate part of this growth. However, world economic activity has plummeted, and natural gas consumption may be repressed for some time before recovering. The reason for high natural gas and crude oil prices negative relationship with the economic activity had many reasons. According to Gulick (2008), there is a long-term relationship between natural gas and crude oil prices. Manufacturing, substitutable markets, and rivalry for infrastructure and resources are all factors that contribute to this relationship.

Furthermore, because all oil market activity is priced in US dollars, oil prices are influenced by the value of the US dollar. As the value of the dollar decreased against other currencies (depreciated), increased pressure on the price of oil was applied to preserve economic parity between domestic and international oil output. The dollar's value dropped in 2008 when crude oil prices jumped to above \$140 a barrel before reversing course; natural gas prices followed a similar path. On the other hand, natural gas prices were dropped sharply in March 2020 as of the greatest crisis of coronavirus pandemic to reach an average

of 12\$, but this reduction were temporary and natural gas prices are still continued to increase, as can be seen in 2021.

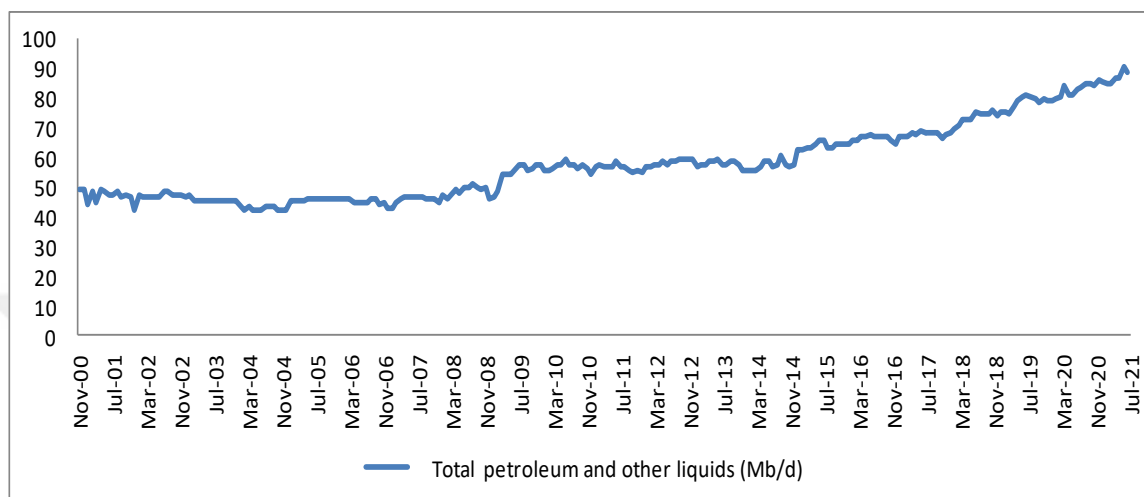
3.3 Total Petroleum and Other Liquids Production Indicator

Turkey is well positioned to act as a hub for oil and natural gas exports from Russia, the Caspian area, and the Middle East to Europe and other Atlantic markets. Turkey has always been a major oil transit point. Caspian oil is transported by ship to Black Sea ports and subsequently to Western markets via the Turkish Straits. Turkey is well positioned to become a major natural gas pipeline center. However, because expanding demand has left little natural gas for export, the majority of its natural gas pipeline connections now solely carry natural gas into the nation. Turkey has seen some of the greatest growth in overall energy demand among OECD nations since 2010. Unlike many other OECD nations in Europe, Turkey's economy has spared the chronic stagnation that has plagued most of the continent in recent years. Turkey produced an estimated 80 Mb/d per day of petroleum and other liquids in 2021, accounting for around 7% of the country's total oil consumption (EIA, 2021).

Figure 6 provides information from EIA (2021) Survey about total petroleum and other liquids production (Mb/d) of Turkey covering the period from Nov 2000 to July 2021. It is clear that total petroleum and other liquids production of Turkey was influenced by various factors to different degrees, with the most influential factors as the fluctuations in nominal exchange rate against the dollar, which contributed to the appreciation and depreciation in the Turkish lira which in terms affects its exports and imports in different ways. However, Figure 6 showed high productivity in total petroleum production in 2021 with an average of 80-90 Mb/d. This was followed by a drop in crude oil price in March 2020 as a result of COVID-19 crisis. Turkish energy market was faced by an efficient production in recent years to reach a high average.

Figure 6

Total Petroleum Production in Turkey (Nov 2000- July 2021)



Note. From US Energy Information Administration (EIA, 2021), accessed on Nov, 2021 from <https://www.eia.gov/international/data/country/TUR>

3.4 Inflation Rate CPI Index

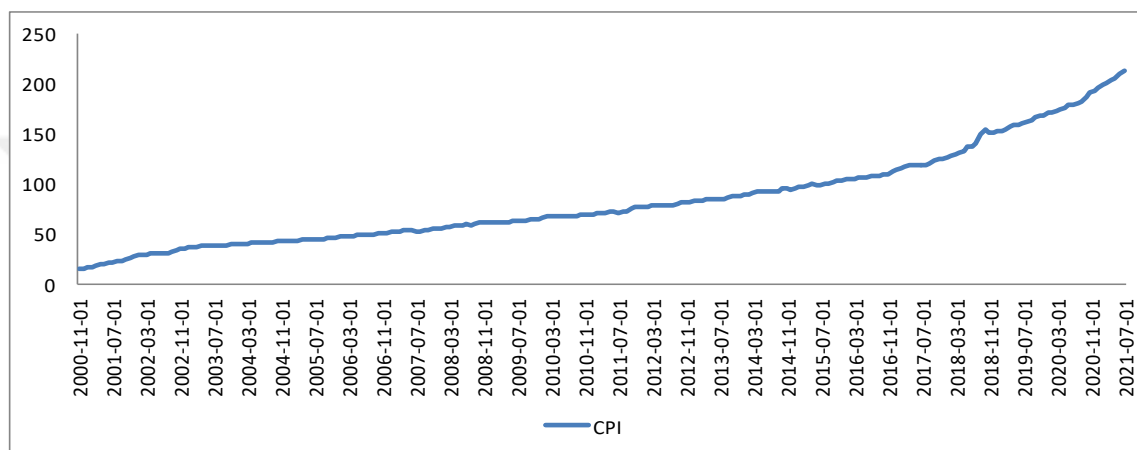
Inflation refers to rise overtime in the general level of product and service prices in an economy. Each unit of the economy purchases less goods and services as the overall price levels rise. Thus, inflation reflects disintegration within the acquiring control of price within the economy. The inflation rate is a significant indicator of market inflation, the annualized change rate in a general price record, which measured by the consumer price index. Inflation has positive or negative impacts. Whole Price Index (WPI) and Consumer Price Index (CPI) are the two indicators of inflation. A list of the prices that producers paid for various inputs can be derived from the WPI. CPI is the amount of money needed to purchase a specific assortment of consumer goods and services.

Figure 7 shows the values of CPI for Turkey, which is considered as indicator for inflation rates in the country. The chart analyzes data of 21 years between 2000 and 2021. It is clearly observed that CPI was increasing over the years. In 2015, the consumer basket was priced by 100 dollars on average. Moreover, the graph shows a steady increase in the measurement over years. However, the measurement of inflation rate shows a gap between

2019 and 2020 (start of the coronavirus pandemic). The indicators show that the CPI is increasing in 2021 and reached 213\$, approximately.

Figure 7

Consumer Price Index of Turkey (Nov 2000- July 2021)



Note. From Federal Reserve Bank of St. Louis (2021). Consumer Price Index: All Items for Turkey, Index 2015=100, Monthly, Not Seasonally adjusted”, accessed on Nov, 2021 source from <https://fredhelp.stlouisfed.org>

Oil importing countries that import large portions of their oil consumption face negative trends by oil price shocks, such as an extreme rise in inflation, and have a negative impact on both domestic demand and the balance of foreign payments made to countries. Manufacturing companies, for example, use oil intensively, especially to cover their transport needs; there is an increase in inflation values in the oil production as they face an increase in production costs. Many countries were adversely impacted by rising oil prices during the first oil crisis encountered in the early 1970s that is because of production costs, oil supply shortages would have an adverse impact on inflation (Eurostat, 2019).

With regard to the developments in the Turkish economy, Turkey's inflation rate clearly grew after the first oil crisis. From 1979 to 1980, inflation rose as the world was affected by the second oil shock. Turkey was able to meet only about 5% of its total oil needs in terms of output during this time. Economic policies caused a sharp decrease in the inflation rate from 100% to 30-35%, although global oil prices reduced to the minimum in

1986. It was estimated that oil prices reduction had an insignificant effect on output rate. The studies carried out in that era concluded that the rise in oil prices did not lead to a decline in their economic impact; this effect was naturally asymmetric (Hamilton, 1983).

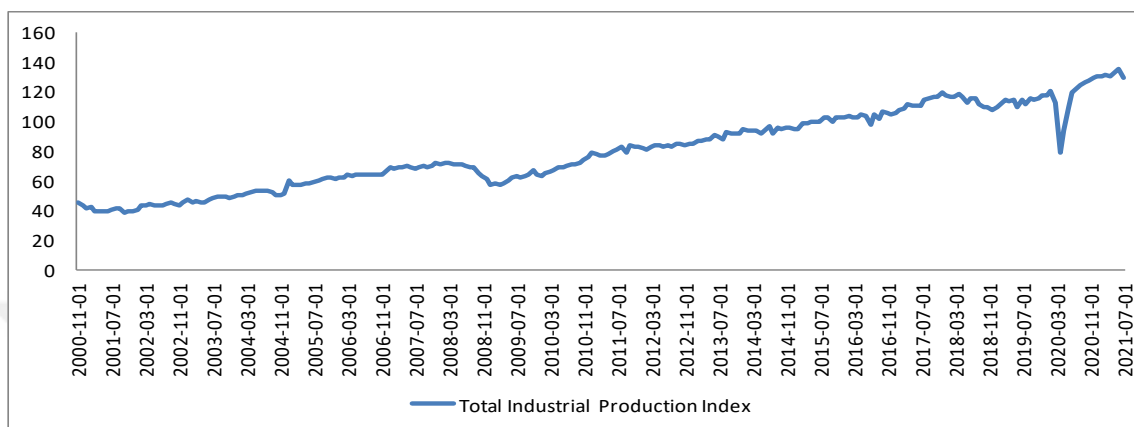
3.5 Total Industrial Production Index

The study used total industrial production index of Turkey as a proxy for GDP since the monthly data of GDP for Turkey is unavailable. The industrial production index is a metric that evaluates real output in an area for a given sector or group of industries. Turkey's industrial production index increased by 13.8 percent in 2021 up from an upwardly revised 9.7 percent in 2020, exceeding market estimates of 10.5 percent. Capital goods, intermediate products, durable consumer goods, and non-durable consumer goods all had faster increases in real output. Meanwhile, energy production declined. Industrial activity increased 5.4 percent on a seasonally adjusted basis (Federal Reserve Bank of St. Louis, 2021).

Figure 8 shows the total industrial production index of Turkey between Nov 2000 and July 2021. From Figure 8, there is a positive trend for total industrial production index of Turkey. However, there are two sharp decreases the first decrease was in 2008 as of the greatest financial crisis in 2008, the second recent decrease was in 2020 as the effect of coronavirus pandemic crisis. As the pandemic start to spread in March 2020 in Turkey the industrial production index faced a huge decline in April 2020 which was about an average of 78 after the high levels that were registered at an average of 120.

Figure 8

Total Industrial Production Index of Turkey (Nov 2000 – July 2021)



Note. From Federal Reserve Bank of St. Louis (2021), accessed on Nov 2021 from <https://fred.stlouisfed.org>

3.5.1 The association between crude oil prices and GDP economic growth

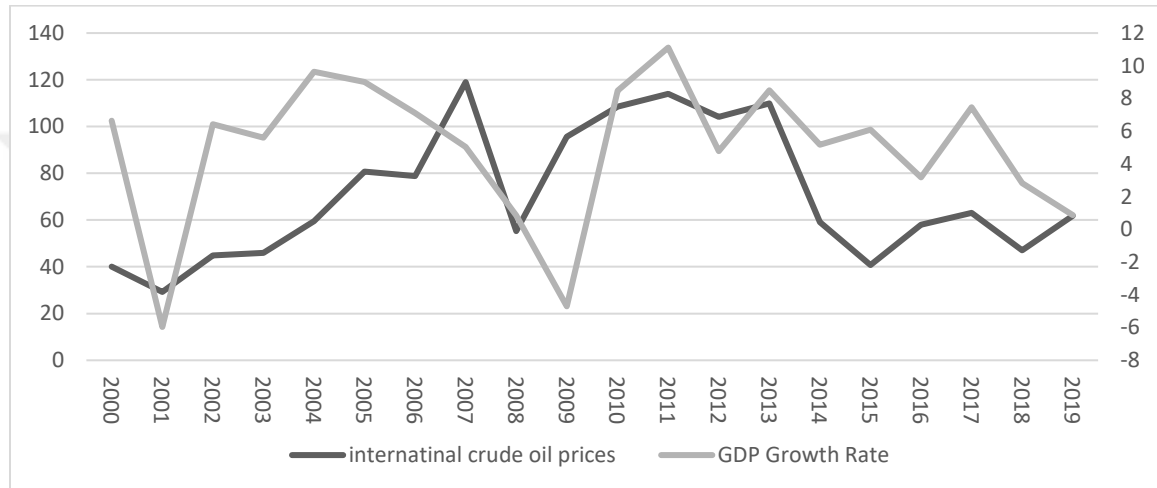
The gross domestic product (GDP) measures the monetary value of all finished products and services produced within a nation's borders during a specific time period. GDP integrates the overall esteem of the object in order to dodge double-counting, but not the pieces that go into it. Person consumption (C), investment (I), government spending (G), exports (X), and imports (M) are all components of GDP. In OECD (2020b) reports, GDP of Turkey comes to 205 USD, GDP deflator of Turkey expanded 10.4 %, and GDP Per Capita comes to 9,127 USD in 2020.

Crude oil has continuously been a marker of economic solidity, primarily due to the high reliance of the world on oil products. Moreover, the price of oil is the fundamental value of today's world economy, considering that oil is the largest commodity traded globally. Furthermore, the prices of other replaceable energy items are related to the price of crude oil. For these factors, oil price fluctuations have wide-ranging implications for both oil-exporting and importing nations. Figure 9 shows a starting point for analyzing the actions of oil prices and the relation with Turkey's economic growth over the past 20 years. The graph shows annually Brent oil prices and GDP growth, the chart has experienced a low level of GDP rates with the increasing Brent oil prices until year 2015, before crude

oil prices collapsed in the following five years, while experiencing an increase in GDP Growth.

Figure 9

Crude Oil Price and GDP Growth Variances / Turkey (2000-2019)



Note. From OECD (2020b), Federal Reserve Economic (2020), accessed on April, 2020 from <https://fred.stlouisfed.org>

1. *The impact of GDP on crude oil prices*

The influence of GDP on oil prices can be seen in view of the control of oil market. Indeed, as world economic growth increases the demand for oil increase, this increases the price of oil. Because of varieties within the trade cycle, oil prices at that stage appear to be unpredictable. Since oil is exclusively traded in dollars and the weakening of the national currency against the dollar has increased oil costs, the decline in the dollar's appreciation against other currencies supports the expansion of oil consumption in other nations (Dik-kaya and Doyar, 2015).

2. *The impact of crude oil price on GDP*

In 2000, 2004 and 2008 crisis, the fact of oil price fluctuation was experienced. A rise in oil prices should be considered positive in oil exporting countries and negative in oil importing nations, all things equal. The impact of global demand will depend on how much of the additional revenue received by exporters of oil is reallocated. Higher oil prices

and the opposite for oil importing countries gave a boost to economic growth in oil exporting countries, so that the net effect was continually negative. Due to negative net exports, the growth of the world economy has continuously dropped sharply during the oil price upturn (Dikkaya and Doyar, 2015). Overall, the solution for stable economic growth is the stability in crude oil prices.

3.6 Nominal Exchange Rate Indicator

Exchange rates are the value of the currency of one country relative to the currency of another country. This indicator is calculated per US dollar in terms of national currency (OECD, 2020b). The nominal exchange rate, which represents the relative price of two currencies, is the first sort of exchange rate that economists categorize. The real exchange rate, which is the second category, is a metric used to determine the relative costs of goods and services produced abroad in order to determine international competition in relation to products and services produced domestically. This international competition is an example of how exchange rate depreciation affects relative prices by increasing exports while decreasing imports.

However, exports suffer as a result of exchange rate appreciation, while imports benefit. For example, the weakening of exchange rates triggers the transition of income from importing countries to exporting countries, which affects both importing and exporting countries' economic development (Bloom, David, Canning, and Sevilla, 2001). As the basic input of daily energy, national economies need oil. Oil price increases have an effect on input prices, influencing the general level of prices and output. This is consistent with exchange rate fluctuations that have a direct influence on global economies.

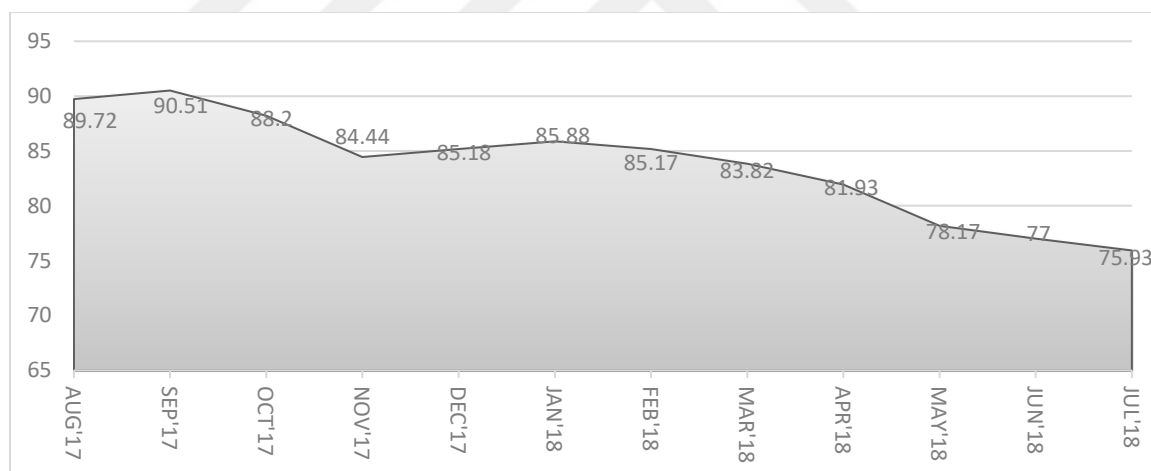
This section of the study focuses on how the global and Turkish economies are affected by the price of crude oil and the exchange rate. The ties between economic growth, crude oil prices, production, and exchange rate are studied by Gülay and Pazarlioğlu (2016). They discover a negative relationship between the exchange rate and Turkish economic growth. Economic stability is influenced by volatility and uncertainty in exchange rates which is from an economic stability point of view, an indication of economic destabilization.

In Turkey, monthly average of 113.3 between 1994 and 2020 is revised in the Real Effective Exchange Rate index given by the Central Bank of the Republic of Turkey as a deflator of CPI (CEIC, 2020b). The real effective exchange rate index of Turkey, as reported by (CEIC, 2020b) in the most recent updated data for 2017 and 2018, is depicted in Figure 10.

The findings in Figure 10 show that Turkey was subjected to real exchange rate fluctuations. In providing economic stability, these fluctuations will trigger problems. The domestic inflation rate, tax rate, and productivity factor changes all corresponding to changes in the real exchange rate.

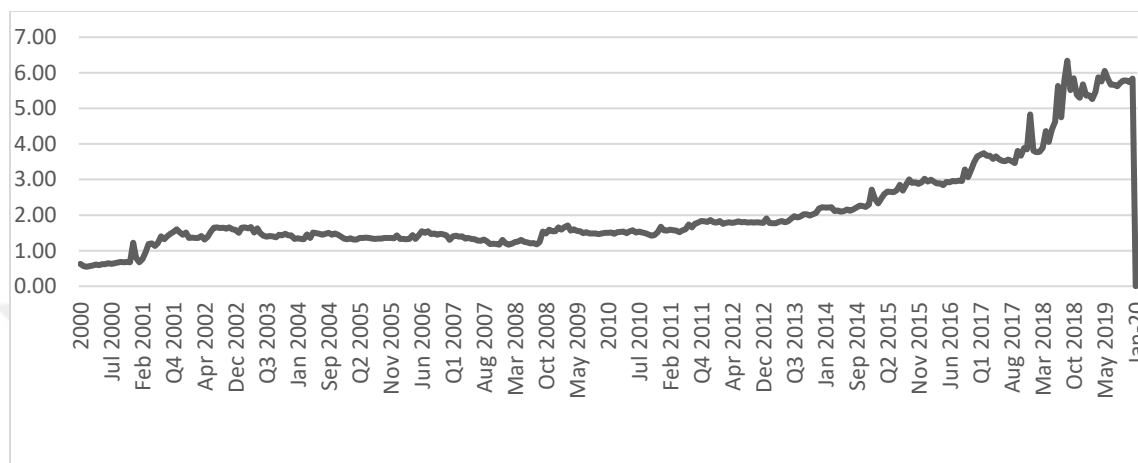
Figure 10

Real Effective Exchange Rate Index of Turkey: Monthly (Aug 2017-Jul 2018)



Note. From “Central Bank of the Republic of Turkey”, accessed on Sep, 2020 from <https://www.ceicdata.com/en/turkey/real-effective-exchange-rate-index>

Figure 11 displays the real exchange rate fluctuations in Turkey between 2000 and 2020. Turkey's real exchange rate seems to be increasing since 2001. The increase in the real exchange rate is a fundamental factor in Turkey's current account deficits. Given the dire circumstances and the severe pandemic crisis, the reduction in the real exchange rate in 2020 points to a decline in the competitiveness of the Turkish economy over the previous year.

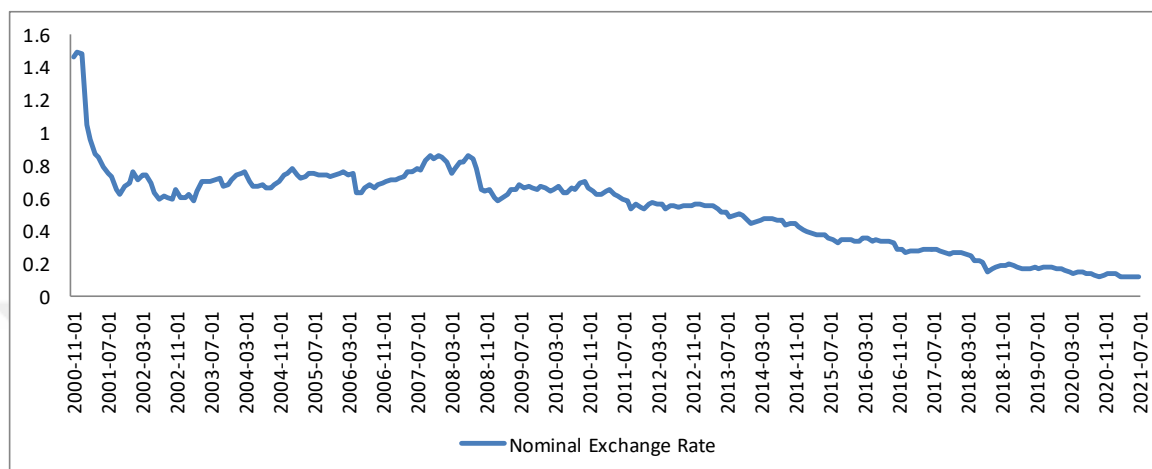
Figure 11*Real Exchange Rate of Turkey: Quarterly (2000-2020)*

Note. From “Trading Economics”, accessed on Nov, 2020 from <https://tradingeconomics.com/turkey/real-effective-exchange-rate-wb-data.html#>

For several factors, many politicians take an interest in nominal and real exchange rate behavior. One of these issues is that the instability of nominal exchange rates influences the inflation rate and has an effect on the welfare of households and the distribution of capital, which are very important factors in assessing countries' economic development. Figure 12 shows the nominal exchange rate of Turkey against dollar for the period of the study from Nov 2000 until July 2021. It is clear that the Turkish lira is suffering from huge depreciation against the US dollar especially in 2021 as of COVID-19 pandemic effect and the Turkish economy's enormous current account deficit and massive quantities of private foreign-currency denominated debt.

Figure 12

Nominal Exchange Rate TRY/USD (Nov 2000 – July 2021)



Note. From Investing (2021). Exchange rate lira to dollar data. Accessed on Nov 2021 from <https://www.investing.com/currencies/try-usd-historical-data>

3.7 Petroleum and Natural Gas Imports and Exports

It can be seen that significant fluctuations in international crude oil prices imports, apart from exports of petroleum products, have experienced steady growth primarily to meet the domestic demand of the economy. As seen earlier, with a significant increase in oil capacity in Turkey, exports of petroleum products have increased since 2002, although the downturn in the global economy caused a short decline in 2008. Turkey's oil imports mostly come from India 11.12%, Iran and Iraq 17.08%, and the Russian Federation 25.21%. Crude oil and diesel oil make up more than 89% of Turkey's imports of petroleum products. However, Egypt of 10.61%, Spain of 9.85%, Malta of 5.73%, and the US of 4.29% are receiving the most of Turkey's oil exports.

Turkey's EMRA said that oil imports are the highest oil import volume jumped 22.7 percent to cross 2.68 million tons. Turkey imported the largest volume of crude oil from Iraq in January 2020 with volume of 741, 309 tons. Furthermore, Russia and Kazakhstan followed with oil import volume of 498,546 and 413,547 tons, respectively. Additionally, at the first period of coronavirus pandemic, oil production increased by 23.7 % to reach a volume of 2.88 million tons. Although diesel production increased by 55.9 % to reach a

volume of 1.27 million tons, however, gasoline production declined by almost 7.4 % to reach a volume of 413,930 tons. In January 2020, compared to the same month of 2019 pre pandemic, total domestic oil product sales increased by 7.6 % to 2.12 million tons.

3.7.1 Structure for the domestic sector of Turkey and present development in the industry

According to the Turkish Constitutions, the Turkish State is entitled to authority over natural resources. By issuing licenses, the State will grant legal organizations the authority to discover and use natural resources. Depending on the kind of activity and the natural resource, licensing is handled by EMRA and GDPA. The Turkish Petroleum Corporation and the Petroleum Pipeline Corporation of Turkey are two state-owned businesses that control the import and export of petroleum products, respectively. Due to a lack of substantial oil and gas infrastructure, Turkey's need for imported energy is generally satisfied. As the Turkish government works to gradually globalize the oil and gas markets and lessen the dominance of state-owned public institutions, the market shares of local private enterprises in both sectors will rise in the near future.

The liberalization of the oil and gas industries is a top priority for the Turkish government since it will eventually create a competitive environment where private enterprises can enter the market. Turkish Petroleum and Natural Gas Market Law and the associated secondary legislation are aimed at enhancing competition and facilitating entry and operation of domestic and foreign players in the relevant markets. The Minister of Energy and Natural Resources emphasize the significance of lowering Turkey's reliance on imported resources and improving natural gas storage capacity.

Turkey wants to establish itself as a hub for natural gas trading in the area. To do this, Turkey is concentrating on enhancing its technological infrastructure capabilities and broadening its market opportunities. The legal framework for the creation of a natural gas organized wholesale market was finished in 2017, and in April/2018 the entire natural gas organized market began operating. Additionally, the natural gas storage capacity will be increased to meet at least 10% of the projected annual gas demand in 2019 and even up to 20% over the longer term. The Natural Gas Sector Report states that Turkey generated

428.17 million cubic meters of natural gas last year. Turkey has not yet begun to generate liquefied natural gas since they should have to find and use indigenous unconventional oil reserves.

Turkey imports 47 percent of its natural gas from the Russian Federation. Turkey imported 22.5% of the world's natural gas as liquefied natural gas (LNG) in 2018. In addition, spot LNG accounts for 45% of Turkey's LNG imports, with the remaining volume coming from Algeria and Nigeria via the Petroleum Pipeline Corporation. In 2018, Turkey obtains more than half of its natural gas from the Russian Federation about 23,642 million cubic meters. However, Turkey only sends natural gas to Greece since its own supply is so restricted about 673 million cubic meters.

In 2018, Turkey consumed 28.2 million tons of domestic crude oil output, which only met about 7% of its oil requirements. Furthermore, domestic natural gas output accounted for just 0.87% of national demand. Therefore, domestic production is inadequate to cover the domestic energy needs of Turkey. For that reason, Turkey depends heavily on oil and gas imports to supply oil and natural gas consumption in the country.

3.7.2. Oil and Gas Government Organizations of Turkey

The following public regulatory agencies are in charge of overseeing oil and gas extraction:

1. Energy Market Regulatory Authority (EMRA)

The oil and gas markets in Turkey are governed and supervised by EMRA, an independent regulatory body. Additionally, this authority issues licenses to traders in the oil and gas markets. In order to guarantee a fair market environment and to establish obligations for market participants, they permitted to put into effect and enforce the relevant regulations and issue fines.

2. Ministry of Energy and Natural Resources (MENR)

Assessing, analyzing, and planning Turkey's short- and long-term needs for energy and natural resources fall primarily under the preview of MENR. The ministry oversees market activities such the production, development, exploration, extraction, and distribution of energy and natural resources.

3. *General Directorate of Petroleum Affairs (GDPA)*

GDPA is one of the principal support organizations established under the aegis of MENR. They are in charge of awarding exploration and exploitation permits and also manages the petroleum and natural gas upstream markets.

4. *Ministry of Environment and Urban Planning (MEUP)*

In order to ensure environmental security, MEUP is responsible for setting those environmental standards. In order to ensure compliance with the relevant requirements, MEUP is allowed to enforce and conduct investigations.

5. *Ministry of Family, Labor and Social Security (MFLS)*

The MFLS is allowed to perform investigations in order to ensure that workplace occupational health and safety steps are properly taken in Turkey.

6. *Governmental System of Oil and Gas Privileges*

The primary regulatory body for these operations is MENR and GDPA. Value added tax is exempted for international oil and gas transported by transit pipelines in Turkey. Oil and gas imports are subject to the value added tax. Vehicle, fuel-related, and licensing-related imports are exempt from taxes. There is no duty on the importation of oil and gas from EU members or the European Free Trade Union. Turkey does not impose any tariffs on its oil and gas exports.

3.7.3. International Oil Price Shocks and Its Effect on The Turkish Energy Market

As a nation that relies on natural gas, Turkey has an increased use of gas along with a rise in imports of oil and gas, which increase uncertainty with the situation resulting from falling oil and gas prices. Over the previous years, Turkish economy had a growth about an average rate of 5%, which represented the leader of energy demand and investment in the Turkish oil market. The coronavirus pandemic crisis in 2020 leads to a decline in the international global gas prices. Turkey now has the potential to reduce its dependence on its special suppliers, to create a dynamic market for gas. Turkish energy sector alterations have enhanced private investment projects and improved economic growth and energy entrance. Electricity in Turkey and Europe has been incorporated into the gas and electricity

trade. Moreover, by building the Trans-Anatolian Natural Gas Pipeline, which will transfer gas from the Caspian Pipeline to Turkey and the European Union, there will be trade routes. The IEA urges Turkey to complete the liberalization of its markets for energy and gas in order to attract investment. Turkey should also create independent transmission system operators, competitive wholesale markets and promote productive transmission system operations (IEA, 2020).

Crude oil role in investment escalates the demand for appropriate movement with other economic assets. Mustivaya (2012) explored the relationship of crude oil price with costs of four product market (gasoline, natural gas, gold and Industrial Index). The proposition got results from applying wavelet coherence model, which revealed a flow of interconnection between commodity prices and crude oil price. Investigation brought numerous imperative discoveries and suggestions as introducing the investment horizons that should be taken into consideration to leap differentiation features of the four commodities. In terms of both exports to obtain cash inflows and imports to meet internal energy demand, emerging economies depend heavily on energy commodities. Due to its direct effect on foreign cash in and out flows, volatility in oil prices on international markets could spill over to the net cash balance of individual countries, which could increase the overall fragility of countries. Turkey is directly impacted by the developments in energy prices on international spot product markets due to its considerable relief. The monetary policy and financial indexes of the country respond immediately to changes in external factors, such as commodity prices.

Both developed and developing economies, irrespective of their status as importers or exporters, are heavily dependent on the prices of energy commodities. When it comes to developing economies, their reliance on oil prices is considered highly important, considering the importance of foreign funds for their financial sustainability. Although the position of importers in the current spot market is dictated by energy prices, the size of their individual energy bills raises their current account deficit. In the position of exporters, the inflow of their funds depends on spot prices by calculating the size of the national income from energy product exports. The fluctuations in the prices of energy resources on

the international spot energy markets have a direct effect on countries' current account balances and thus, on their economic fragility.

Financially, crude oil prices affect the condition of borrowers who participate in business activities as entrepreneurs with insufficient capital to make decisions. Accordingly, credit rating institutions assess the fragility levels of developing countries that are highly dependent on global capital markets and are seen as a significant predictor for foreign investment. Capital markets measure the weakness of countries by taking different economic measures into account (Işikli and Akin, 2017). Throughout this context, influential credit rating agencies track developing countries dependent on foreign capital in terms of their macroeconomic indicators for classification based on their individual risk exposure. Following Turkey's nomination as one of the world's five most vulnerable countries, Turkey could be seen as an economy more sensitive to changes in international spot energy commodity markets due to Turkey's net energy importer economy (Işikli and Akin, 2017). Turkey's financial and macroeconomic indicators, especially the current account balance, respond to external factors such as changes in the price of energy commodities.

Oil prices have been primarily taken into account in the existing literature on the effect of energy prices on economic and financial indicators due to their important position among the world's energy supplies. Generally, not only crude oil, but also oil substitutes such as petrol, diesel, as well as natural gas, methanol, ethanol, electricity, coal, bio-fuels, is limited to global energy resources used by countries around the world. While crude oil is still a fundamental energy input for the country in this context, economies have embraced a large-scale approach to energy prices by incorporating the effects of fluctuations in the prices of other energy commodities, rather than considering crude oil prices alone.

As can be recognized in Chapter 3 that Turkey is directly influenced by the developments in energy prices on foreign commodity markets due to its substantial dependence on imported energy. The cost of production has increased as a result of rising oil prices and the value of the US dollar, which could cause inflation to rise. Currency rates in nations with severe financial instability are particularly affected by energy price variations because they increase the perception of risk measure. With rising domestic energy costs and the

ensuing inflationary pressure, rising energy prices are predicted to increase energy use and negatively impact macroeconomic factors.

On the other side, a drop in oil prices would favorably affect Turkey's energy consumption and current account. Conflict arises between the world's major economic powers as a result of variations in the price of oil. The drop in oil prices has increased the financial strain on oil-importing nations, especially as a result of the financial crisis in oil-exporting nations' break consequences. The COVID-19 epidemic and its impact on the stock and energy markets will be covered in the following Chapter 4. Additionally, each parameter will be identified as the Brent oil price, VIX, and BIST-100.

CHAPTER 4

ASSESSING DYNAMIC AND LONG RUN IMPACTS OF COVID-19 ON TURKEY'S STOCK AND OIL MARKETS

COVID-19 has had an unprecedented effect on nations and economies since 2020. This pandemic leads to a growing perception of risk and uncertainty in financial markets. As a result, spontaneous decision-making is becoming less precise in determining the duration and depth of the economic impacts of the health crisis. Wuhan, China (Hubei region) is the epicenter of the latest coronavirus outbreak (COVID-19), which spreads swiftly around the globe. The virus had killed thousands of individuals as of March 11, 2020, and infected over 100,000 people across more than 100 countries (WHO, 2020). The first infected case in Turkey was announced on March 11, 2020. During this time, the government imposed a curfew across the entire nation, which had an adverse effect on trade, travel, agricultural, production, and the transport sectors, leading to local food shortages and overcrowded healthcare institutions. In addition, at beginning of February 2020, crude oil and stock markets saw multiple shock waves, and financial volatility in BIST-100 stock exchange continued to rise in the context of COVID-19 uncertainty.

The current study intends to investigate the impact of COVID-19 crises on Turkey's stock and energy markets. BIST-100 and VIX will be employed in this case to represent the stock market, and the price of Brent Crude oil will be examined to represent the energy market. The study concentrated on these indexes as they are the most affected during the pandemic period. A tremendous decrease in crude oil prices with low demand as of the curfew restrictions applied in Turkey, lead not only to depreciation in Turkish lira, but also to a downturn in all economic sectors. Moreover, the pandemic leads to high uncertainty in economic activities which affected investors and traders' financial and economic expectations.

However, the study's focus is on the impact of COVID-19 daily infected cases on stock and energy market indices, therefore it only included these variables because they are readily available on a daily basis, as opposed to most data, which are more affordable on a monthly or quarterly basis. Based on the extensive literature review done for this study, we did not come across another study investigating a similar relationship for the

same time period between COVID-19 crisis and stock and energy markets. As a result, this paper is going to be the first thesis investigating the relationship between COVID-19 crisis and stock and energy markets in Turkey between March 2020 and April 2021, in the literature. As a result, we expand on Albulescu (2020a) and broaden his approach in a number of ways. First, the analysis examines the short- and long-term connection during the pandemic between March 11, 2020 and April 12, 2021 by using daily data for COVID-19 infection cases and other dependent variables. Additionally, the analysis takes into account the most recent infection case numbers from Turkey and uses the VIX volatility, BIST-100, and BRENT fluctuations as proxies for changes in the country's financial markets and oil prices.

Based on our findings, it's critical to examine COVID-19's impact on a country's public health and well-being as well as its economics. Because following these economic shocks country's public health systems fail and result in the death of many citizens. According to McKibbin and Fernando (2020), poor public health may result in the death of people from any socioeconomic group in any community if infections are brought on by population increase in underdeveloped countries. However, governments still fail to see the need for development and public health funding, as well as the fact that investing in public health improves living conditions and stimulates economic growth.

Moreover, the influence of COVID-19 outbreak on the BIST-100 returns is investigated by Karaca et al. (2020) who showed that the majority of sectors have realized negative returns where sports, tourism, and transportation sectors losing the most. Early estimates of the COVID-19 epidemic's costs in terms of the economic effects of coronavirus transmission were provided by McKibbin and Fernando (2020). While the disease outbreak lasts, central banks and financial ministries must make sure that damaged economies continue to run in the short term even that Longer-term consequences are much more essential.

4.1 Economic Forecast of the Effects of COVID-19

While humans face a number of epidemics as in 1889, 1918, 1957, and 1968 after the industrial revolution, comparing the COVID-19 pandemic to those of the Spanish flu, SARS, MERS, Ebola, swine flu, Zika, and yellow fever, it has had an extraordinary impact

on countries and industries in 2020. This pandemic leads to a Growing perception of risk and uncertainty in financial markets and the need for emergency decision making are becoming more uncertain about the duration and depth of the economic impacts of the health crisis.

In addition, market declines are being intensified by worries about the worldwide epidemic and the effectiveness of public initiatives intended to promote its spread. Corporations are delaying investment decisions with the growing number of cases. A historic decline in crude oil prices, which reflects the global decline in economic activity, has been accompanied by the economic crisis. In addition, these conditions are leading to disinflation, which also contributes to the weakening of the global economy across several industries. The Federal Open Market Committee stated on April 29, 2020 that the present public health crisis will have a significant negative impact on economic growth, employment, and inflation in the short term and pose significant threats to the economic outlook in the medium term. The demand for commodities like oil is falling, and a number of economic activities have experienced dramatic declines. This situation provides a supply-side obstacle to declining demand because of COVID-19. Table 4 displays coronavirus disease cases for several countries as reported by (WHO, 2020), organized by the number of new cases, deaths, and totals.

Table 4*Coronavirus Disease (COVID-19) Situation by country*

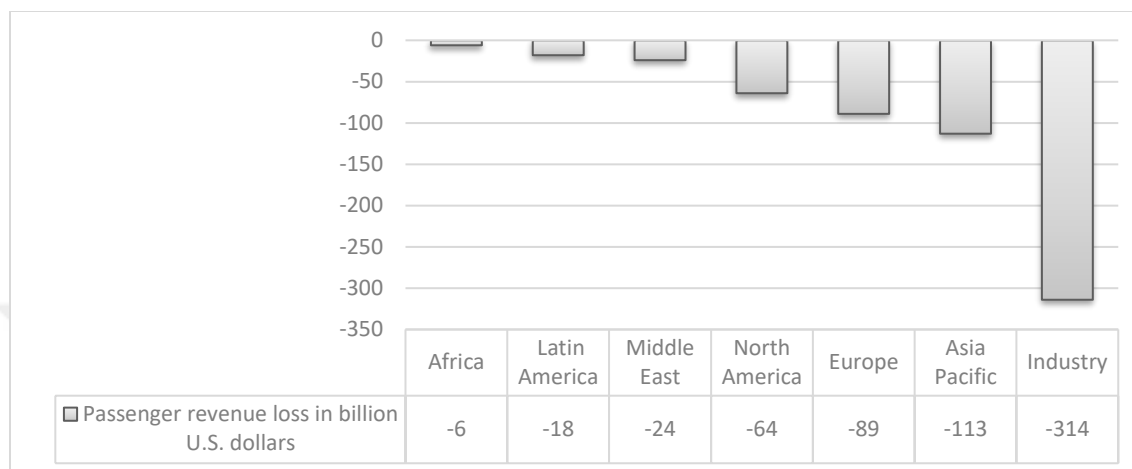
Cases	Cumulative cases	Newly reported (Last 24 hours)	Death (Cumulative)	Deaths newly reported (Last 24 hours)
Global	59,204,902	481,818	1,397,139	8,241
USA	12,276,834	157,180	255,850	1,052
India	9,222,216	44,376	134,699	481
Brazil	6,087,608	16,207	169,485	302
Russian	2,138,828	24,326	37,031	491
France	2,106,660	4,150	48,883	499
Spain	1,556,730	0	42,619	0
Turkey	453,535	6,713	12,511	153
Bangladesh	451,990	2,230	6,448	32
Israel	329,286	749	2,810	14

Note. From “World Health Organization”, WHO, reports accessed on Nov 25 2020 from <https://covid19.who.int/table>

Airline flight sector revenue were affected by COVID-19, the losses due to the pandemic are shown in Figure 13. The world in 2020 as reported in airline registrations, recorded 314 billion USD less than the previous year (Statista, 2020).

Figure 13

Airline Passenger Revenue Losses Due to Coronavirus in World (Billion/\$/2020)



Note. From Statista, 2020, accessed on June, 2020 from <https://www.statista.com/statistics/1106679/coronavirus-airlines-passenger-revenue-region/>

4.2 Crude Oil Price and Coronavirus Pandemic Side View

Oil consumption averaged 94.4 million barrels per day in the first quarter of 2020, down 5.6 million barrels per day from the pre-pandemic period as global oil demand has started to decline (OPEC, 2020b). As the storage facilities were complete, crude oil prices dropped into the negative region because there was almost no place to store the oil. oil prices have decreased in an unprecedented manner due to declining demand in many sectors such as transport and manufacturing. Although OPEC and Russia agreed to cut oil output to raise prices, traders were unable to persuade them that supply could not remain above demand, which allowed the price of WTI crude oil to drop by \$36.98 a barrel and Brent oil prices fell to \$27.6 per barrel (EIA, 2021).

Moreover, WTI crude oil price bounced more than 10% to become over \$26.4 a barrel on April, 2020, in the period of recuperation in worldwide oil demand after information appeared about crude oil imports from China expanded in April. Indeed, as the coronavirus pandemic harmed worldwide demand, in a sign that the nations may recuperate quicker than expected and bolster worldwide growth. Although, disagreements between OPEC members have a role to play in reducing oil prices.

The estimation about Brent crude oil price reported an average of \$35.84 a barrel in 2020. Brent and WTI crude oil both plunged underneath 20% in 2020. Brent oil price was exchanging at around \$25, which is 60 % lower than that of 2019 as lockdown had pounded demand for oil. Table 5 compares Brent oil prices before and after the recovery of the pandemic (Country Economy, 2020).

Table 5

Comparison of Brent Crude Oil Price (2019-2020)

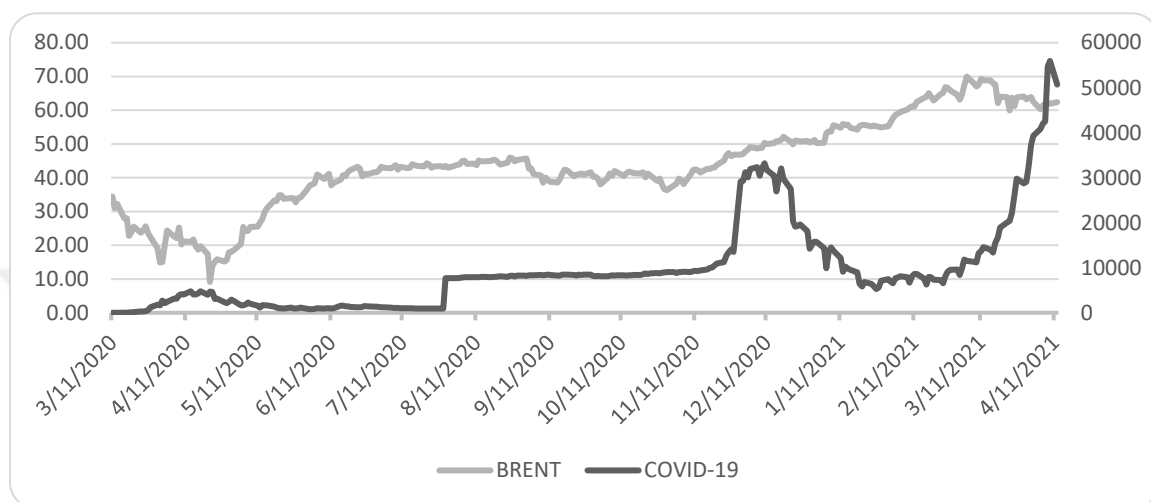
Brent Oil Price (USD/Barrel)		
Date	Price \$	Price €
Mar-20	32.01\$	28.93
Feb-20	55.66\$	51.04
Jan-20	63.65\$	57.34
Dec-19	67.31\$	60.57

Note. From country economy, accessed on 9 Nov, 2020 from [Investing.com](https://www.investing.com) - Stock Market Quotes and Financial News

Figure 14, shows the direction of daily crude oil prices during the pandemic crisis. Figure 14, displays that series were moving in the opposite direction until April 2020. After April 2020, prevalence of COVID-19 cases remained steady while Brent almost quadrupled in 2 months and then remained steady until November 2020. However, there was a rise in the number of COVID-19-infected cases reported each day in November 2020, coinciding with an increase in energy market prices that brought them to their average price (60\$/barrel) pre pandemic.

Figure 14

Fluctuations of Daily Brent Oil Prices and Number of Coronavirus Infected Cases

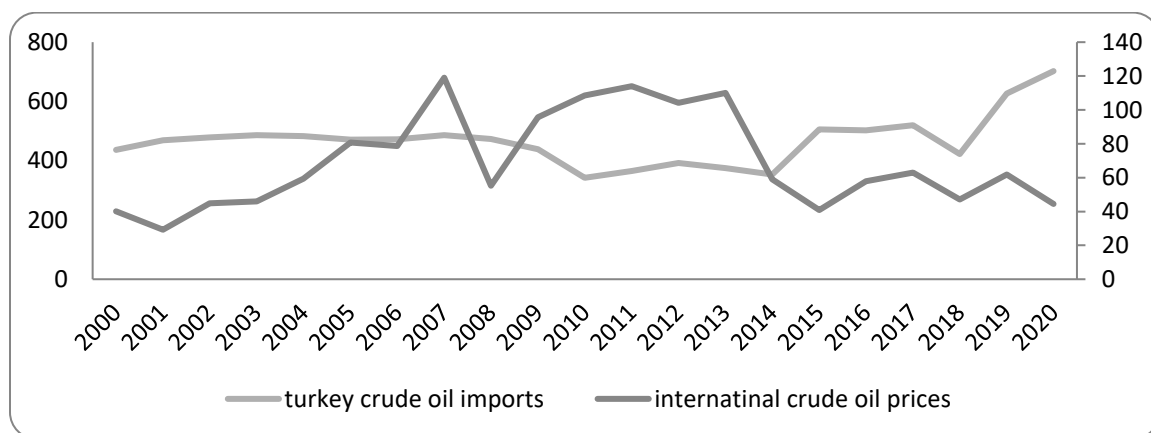


Note. From World Health Organization and Federal Reserve Bank of St. Louis (2021)

Moreover, Figure 15 which illustrates the effect of crude oil price reduction due the pandemic crisis in 2020 and its effect on oil imports of Turkey, comparing 2020 year with the previous years.

Figure 15

Turkey Crude Oil Imports and Crude Oil Prices (A2000-2020)



Note. From Macro trend, crude oil imports, crude oil prices, accessed on Dec 3, 2020 from <https://www.macrotrends.net/1369/crude-oil-price-history-chart>

4.3. COVID-19 Pandemic Impact on Turkey's Economic Growth and National Currency

According to previous pandemic breakouts, each epidemic cost more than one percent of global revenues and had a negative economic impact (Buheji and Ahmed, 2020). Depending on the number of infected people, the mortality rate, the number of jobs lost, the change in consumer behavior toward fewer social activities or social consumption, the drop in worldwide GDP with COVID-19 varies between 1 and 6 percent of GDP. According to OECD (2020c) estimates, the virus's economic effects may boost global economic growth if they didn't worsen in the first quarter. The IMF also stated that many nations are dealing with a multifaceted crisis, which includes a crisis of health, domestic economy, a breakdown of net exports, and a collapse of the commodity markets.

Table 6 shows OECD (2020c) economic forecasts of the Percentage change in Real GDP Growth in some countries as a comparison between 2018 and 2020 quarterly data. The world economy will endure its worst recession since the Great Depression, according to the OECD (2020c) estimates, which was released on April, 2020. This will eclipse the recession experienced a decade ago during the global financial crisis. As can be seen in Table 6, the OECD (2020b) forecasted that the Turkish GDP would decrease by 9% in 2020. However, global trade decreased in 2020 by 11% and oil prices declined by 42%. As a group, industrialized economies are experienced an economic downturn of 7.8% of GDP in 2020, with the OECD (2020b) declared that the U.S. economy declined by 5.9%, almost twice the decline rate experienced during the 2008 financial crisis.

In the Euro area, the GDP growth rate has decreased by 4.4%. Additionally, the rate of economic growth in emerging economies shrank by 2% as a result of deteriorating global trade and commodity prices as well as tighter financial conditions.

Table 6*Comparison of Percentage Changes of GDP Growth (Q2018- Q2020)*

Period	Q3- 2018	Q4- 2018	Q1- 2019	Q2- 2019	Q3- 2019	Q4- 2019	Q1- 2020	Q2- 2020	Q3- 2020
Australia	2.6	2.2	1.7	1.6	1.8	2.3	1.6	-6.3	..
Canada	2.0	1.8	1.5	2.0	1.6	1.5	-0.9	-13.0	-4.6
France	1.6	1.4	1.8	1.8	1.6	0.7	-5.8	-18.9	-4.3
Germany	0.8	0.3	1.1	0.1	0.8	0.4	-2.1	-11.2	-4.2
Greece	1.8	1.7	1.7	2.8	2.2	0.8	-0.5	-15.2	..
Israel	3.3	3.0	3.2	3.0	3.3	3.7	0.5	-8.2	-1.4
Italy	0.6	0.2	0.4	0.4	0.5	0.1	-5.6	-17.9	-4.7
Japan	-0.4	-0.3	0.8	0.9	1.7	-0.7	-1.9	-10.3	-5.9
Korea	2.2	3.2	1.7	2.1	1.9	2.4	1.4	-2.8	-1.3
Turkey	2.3	-2.6	-2.4	-0.9	1.1	6.3	4.4	-9.0	..
UK	1.4	1.2	1.7	1.3	1.0	1.0	-2.1	-21.5	-9.6
US	3.1	2.5	2.3	2.0	2.1	2.3	0.3	-9.0	-2.9
OECD -Eu- rope	1.9	1.2	1.4	1.3	1.5	1.7	-1.9	-14.2	..
OECD - Total	2.2	1.6	1.6	1.5	1.7	1.6	-0.9	-11.7	..
Bulgaria	3.3	3.5	4.2	3.8	3.3	3.1	2.3	-8.6	-5.2
China	6.7	6.5	6.4	6.2	6.0	6.0	-6.8	3.2	4.9
India	6.5	5.7	5.4	5.0	4.4	4.1	3.3	-23.5	..
Indonesia	5.2	5.2	5.1	5.1	5.0	4.9	3.0	-5.4	-3.6
Russia	2.0	2.4	0.6	2.7	1.4	0.3	-0.1	-5.6	..
Euro area	1.6	1.2	1.5	1.3	1.4	1	-3.3	-14.8	-4.4
Saudi Arabia	2.7	4.1	1.9	0.9	-0.6	-0.9	-1.0	-6.1	..
South Africa	0.7	0.2	0.0	1.0	0.1	-0.6	-0.2	-17.2	..

Note. From OECD (2020b). Interim Economic Assessment, accessed on 19 Nov, 2020 from <https://stats.oecd.org/index.aspx?queryid=26674>

By contrast, according to OECD (2020b) estimates, retail and wholesale trade, technological, and real estate services will be the most affected by containment constraints, although there are substantial differences between countries. In addition, large emerging economies and business closures could reduce economic activity by 15% or more; other emerging economies could experience a 25% drop in performance. Moreover, tourism-dependent countries may be more seriously impacted, while countries with large agricultural and mining industries may experience less severe effects. In addition, economic effects are likely to vary across countries, indicating variations in timing and degree of containment.

Moreover, the OECD (2020c) argued that China emergency plan is a significant departure for the growth of China combined with globalization through capital flows, supply chains and foreign investment, magnifies the cost of managing the spread of the virus through quarantines and restrictions on labor mobility and travel. China's global economic status and globalization mean that trade plays a part in spreading the economic effect of COVID-19. More generally, the economic consequences of the pandemic are distributed through three networks of trade. Firstly, as reduced economic activity spreads from intermediate producers of products to producers of finished goods, which spreads directly through supply chains. Second, this decreases demand for products in general, including imports, as a result of an overall decline in economic activity. Thirdly, as a result of a reduction in trade with exporters of goods supplied to manufacturers, this in turn decreases their imports and has a negative impact on the trade and economic activity of exporters.

The Turkish currency will weaken in 2020 and 2021 as a result of the coronavirus pandemic's long-term effects on emerging markets like Turkey. According to the economist Craven (2020), this time period will be a developing market for Turkish currency, performing better than Brazil and South Africa while performing worse than Mexico. The study provided evidence that the COVID-19 crisis, which caused this currency loss, is the worst to have occurred since the Great Depression.

4.3.1 Turkey Response to Coronavirus Pandemic Crisis as an Oil Importing Country

On 17 March, as the Central Bank of Turkey reacted to the negative impact of COVID-19 on the global growth outlook, it reduced its one-week repo benchmark rate by 100 basis points to 9.75%. Emergency measures, however were announced on March 31 to curb the fallout from an increasing pandemic. Next, primary dealers would be able to sell debt they have purchased from the Unemployment Insurance System to the Bank. Thirdly, expand re-discount credits worth \$9 billion to 60 billion lira. Fourthly, introduce extra options for lending just below its policy rate of 9.75%. Fifthly, hold the six-month lira, euro or gold swap auctions lower than the policy rate at an interest rate of 125 basis points. Finally, allow lenders, as collateral for foreign currency loans, to use mortgage and asset-backed securities. Moreover, Government of Turkey on March 18 announced a proposal to assist companies impacted by COVID-19 pandemic of 100 billion-lira (\$15.4 billion). It includes steps to raise minimum pension contributions, ranging from tax cuts and payment deferrals for firms.

When dealing with the COVID-19 pandemic sickness, it is worthwhile to study unstable businesses. Transportation, travel, and tourist industry have always been important industries. In Turkey, these businesses also benefit from a substantial resource of employment and professional workers. In 2021, the traveling and tourism sector provide 2,643,800 energy exploration and production jobs, which is about 9.4% of all employment, and 11.4% of total GDP. With a population of over 83 million and a booming economy, Turkey, travel and tourism provide job prospects. The Turkish economy grew by 0.9% in 2019 to reach \$754 billion, with such a 9127 GDP per capita. Turkey's economy is centered on services, with a proportion of services in the GDP of 71.3% in 2019 (Turkish Statistical Institute, 2020).

In conjunction with COVID-19, the price of oil is declining internationally. This is a crucial period for Turkey because the country's economy is strongly dependent on imported main energy supplies like oil and natural gas, and the present decline in these prices will ensure that the current account deficit is closed. The percentage of imported energy in

the total amount of energy used is approximately 75%, such conditions appear to restrict growth throughout these circumstances (Baffes, 2019).

4.3.2. Coronavirus pandemic effect on oil exporting nations due to oil price fluctuations

Oil exporting can be particularly challenging for nations when the fossil fuel sector is going through a structural downturn. The majority of oil-exporting nations are resource-dependent and have experienced large amounts of debt and multifaceted economic and social instability prior to the current predicament, which will not be able to endure the current crisis on relatively small amounts of government debt. Some countries may find themselves entering a slow decline of unsustainable borrowing as a result of the current trouble because oil exporting developing countries have become increasingly dependent on short term and expensive non subsidized private borrowing in recent years, a significant portion of which is backed by oil debt. A prompt and coordinated response involving both lenders and private financiers is necessary in order to provide financial capacity in oil exporting nations, minimize the dangers of unsustainable debt, mismanagement, and direct investment, and to aid in the transition to a more sustainable future.

Net oil exporting nations experience a historic double blow: a COVID-19-fueled global economic catastrophe and an oil market collapse with WTI prices for US and Brent crude oil briefly becoming negative for the first time in history. Based on an oil price of \$30 per barrel, the revenues from oil and gas for a number of major producers would decrease by around 50 to 85% from 2019 levels, however, depending on prospective business trends, the losses could be higher (IEA, 2020).

Global output and mobility have decreased as a result of the COVID-19 outbreak, which has also had an impact on the oil market. This has led to a significant decline in global oil consumption. Demand decreased by 30% from 2020 to a level that hasn't been seen since 1995 (OECD, 2020c). Due to a significant production shortfall, companies have been searching for locations to store excess crude oil, with the greatest stocks in June 2020. Since then, the demand for storage space has marginally decreased as the effect of production cuts takes hold and the market starts to rebalance. On the supply side, policies and oil-

producing nations react jointly to drops in demand but their reaction has not been sufficient to lower production concurrently with the pandemic outbreak.

4.4 Better Future Post Pandemic of COVID-19

The first consequence of COVID-19 was to drive countries to either partial or full lockdown, resulting in a decrease in weekly energy demand by 3.8 % in the first quarter of 2020, and continues to decrease by 6 % from lockdowns and limits on mobility and commercial activities persist in 2020. With the exception of renewable, global demand for coal, oil and gas all dropped by 8%, 5%, and 2%, respectively. The key reasons for the shrinking of these energy markets have been the shutdown of commercial and industrial activities, restricted mobility and aviation restrictions. The price of Brent crude oil per barrel by April 2020 had decreased to its lowest level since November 2002 (IEA, 2020).

It is reasonable to look at the situation in countries that import oil, especially in Turkey. As the sudden drop in crude oil prices, the current state of the oil market is in favor of oil-importing nations. The low global oil price pattern of 2020 is highly important for countries that import energy like Turkey. It should be noted that low oil prices, synchronized with COVID-19, do not merely have a favorable effect on oil importing countries, such as inflation increases and the current account deficit. This is mainly due to the lower demand for products generated in oil-importing countries by oil-exporting countries. Another significant factor is that with the increase in foreign exchange rates, part of the positive impact from the decline in oil prices is taken back, primarily towards the US dollar. In particular, this is a significant situation for major manufactured goods exporters, such as Turkey, because increasing foreign exchange rates against the US dollar have a negative effect on the competitiveness of these countries. As a manufactured good exporter, Turkey will have an effect on the willingness of companies to buy raw materials, machinery at prices denominated in US\$. The effect of oil price volatility on Turkey's real economic activities is negatively associated with production (Arana, 2021).

One positive outcome of COVID-19 could be the reduction in global CO₂ emissions. Global CO₂ emissions in the first quarter of 2020 were 5 % lower than 2019, and declined by up to 8% at the end of 2020. Another positive effect of COVID-19 is that this

crisis helps countries and their institutions to go forward toward circular economy and more sustainable environment to improve socioeconomic development. Buheji and Ahmed (2020) illustrate that throughout history, epidemics have offered people many problems, but have also brought many obvious and unknown possibilities with them. Coronavirus is no exception, and some literatures foresee the possibilities for a better future brought to the economy by this deadly crisis. These studies review the numerous opportunities brought to the world by this virus and related recent events, such as SARS.

4.5 The Influence of COVID-19 on Turkey's Stock Exchange Market

The study's main contribution is that it is one of the first to examine the effects of the COVID-19 pandemic on the volatility of stock price index (VIX) and Borsa Istanbul index (BIST-100) from the first COVID-19 case including the period after July 2020 until April 2021, which is a crucial topic in finance and capital markets and there are no publications in the literature who studied the effect of the pandemic after July 2020.

4.5.1 Volatility of stock price index (VIX)

This thesis seeks to investigate the effects of the coronavirus pandemic on the Turkish stock market. The volatility of the stock price index is measured as the 360-day standard deviation of the return on the country stock market index (VIX). This index is a stock market index that measures how much people fear taking risk of investment. An increasing VIX index indicates market uncertainty and fast decreases VIX index is obtained from (Bloomberg, 2021). Regular observed daily volatility rates are estimated for the period from March 11/2020 to April 12/2021 for this analysis.

The thesis work to explain the economic and financial effects of COVID-19 on traders, fund managers, regulators, economists and financiers, who expect this research to have a substantial impact on their projects. The advent and dissemination of COVID-19 pandemic across the world has increased the level of uncertainty for nations. Foreign portfolio investment outflows had a negative impact on developing economies, and major stock market indexes have crashed as a result of this situation.

Turkey, as a leading and pioneering economy, has attracted foreign investment and has been hit by COVID-19 pandemic. After the beginning of 2020, the volatility stock market index has been increasing, especially at the beginning of March until the half of

April; Turkey in this period showed a high volatility rate in stock markets, as the infected cases of coronavirus and the uncertainty about the economic situation increased. After this period especially at the end of June 2020 the country faced a decrease in volatility Index because of the reduction of restrictions and removing of the lockdown. Moreover, the fear and uncertainty reduced as the economic activities return back to work. The rate of volatility shows a decline to reach its average of 18 as it was before the discovery of the first case of infection in Turkey, and the reduction of crude oil prices as a result of oil flow in Saudi Arabia oil market in Jan/2020 (Gherghina, Armeanu, Joldeş, 2020).

The thesis studies this index to help government institutions, investors, and traders to be more certain in the development of their economic activities in response to the emergence and dissemination of COVID-19 pandemic in order to mitigate the detrimental impacts on the environment, the state, enterprises, families, and individuals. Local lockdowns, quarantines on suburban districts, and school closures are just a few of the precautions taken. In addition, since the pandemic phase, which began in March 11 2020 in Turkey with the discovery of the first outbreak, the index has been comparatively low.

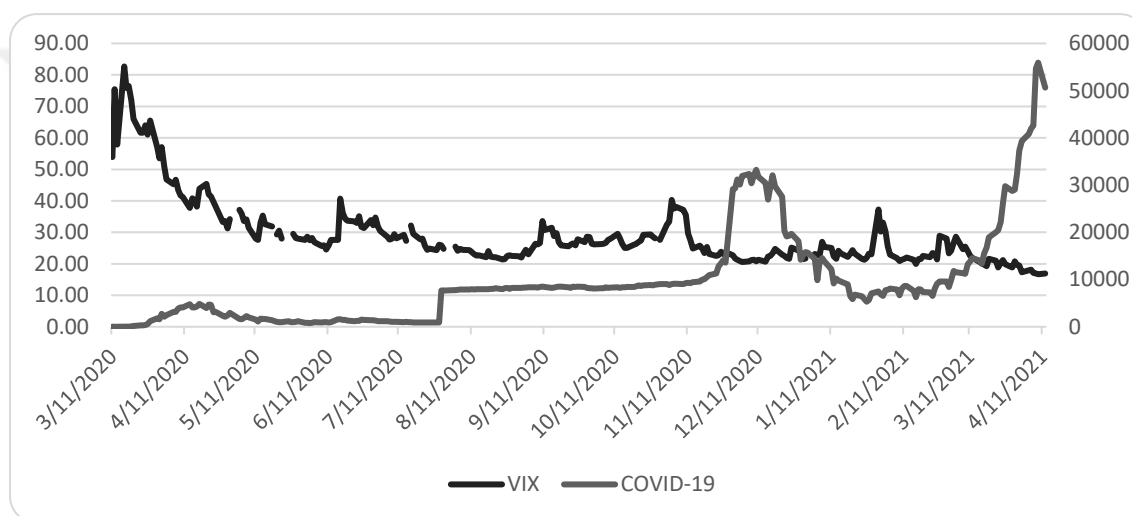
The daily rates of VIX Index during the epidemic are shown in Figure 16. VIX index and coronavirus number of infected cases are moving together in the first period until April 2020, and then negatively flattening until November 2020. However, there was a peak in the number of cases in November 2020 with a downward trend in the uncertainty of the stock market, to reach its average before the pandemic period.

VIX Index is a variable to address how fear or anxieties about the markets influence the sectors operating in Turkey on each specific day. Stock market fluctuations have a pronounced positive relationship with COVID-19 in the long run (Albulescu, 2020b). One possible theory is that as economic activity improves, demand for investment rises, and investor's preferences are boosted by economic activity, which leads to a reduction in stock market uncertainty. The positive association between COVID-19 infection and the volatility index at the beginning of the pandemic in March and April 2020, on the other hand, suggests that as the number of daily cases rises, more countries will begin to restrict both

travelling and economic activity (Albulescu, 2020b). As a result of reduced economic activity, consumer interest will be lost as the world economy becomes more volatile due to lockdown regulations, resulting in greater instability in the stock market.

Figure 16

Fluctuation of VIX Index with COVID-19 Number of Infected Cases



Note. From World Health Organization and Bloomberg.com (2021)

However, in Turkey as can be seen from Figure 16 that VIX goes down suggesting that the uncertainty reduced and investors became more relaxed. Following the impact of COVID-19 pandemic shocks, stock market uncertainty appears to have decreased as a result of the news of economic relief initiatives, which appears to have increased asset markets by lowering investors' risk tolerance and increasing long-term growth predictions.

The research has extensively documented the upbeat response of stock market swings to the COVID-19 epidemic², provided that as the number of infected individuals rises, many countries' prevention measures, such as lock-down and travel bans, contribute to a decline in economic activity. Due to the distortion caused by this pandemic, stock market volatility has increased as investors' interest has declined. The news of economic

² See literature review, chapter 2.5

relief policies seems to have raised asset markets by reducing investors' risk tolerance and improving long-term growth forecasts, resulting in a decline in stock market uncertainty following the effect of COVID-19 pandemic shocks.

4.5.2 Borsa Istanbul-100 Index

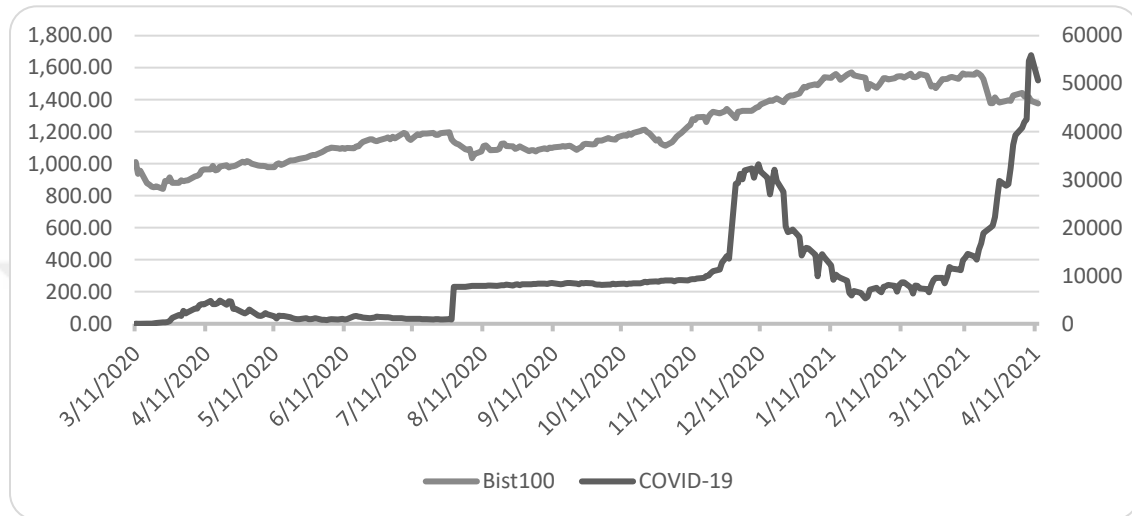
Borsa Istanbul is the sole exchange entity of Turkey; its components are chosen based on the average price of stock market value and average trading value. BIST-100 Index has a base date of January/1986 and a base value of 0.01. In 2013, this significant stock market index that evaluates the performance of 100 firms, integrated with Istanbul Stock Exchange (ISE), Istanbul Gold Exchange, and other derivatives of exchange. The closing price of the trading session is used for the stock indexes in the analysis.

BIST has been growing as a result of the merger, which lead to a market volume of TL 1233 billion as of June 2020, up from TL 505.9 billion at the end of 2013, 2.45% increase. In addition, as of June 30, 2020, the gross traded volume had reached TL 2336.8 billion. BIST stock market has seen an increase in traded volume since May 2020. BIST also includes a number of different indexes. However, the key index, denoted by the symbol XU100, is BIST 100.

Turkey has been in COVID-19 pandemic period with cases and deaths, and the main price market has been declining and seems to be at a low stage. Low-level indexes result in undervaluing of Turkish properties, which is detrimental to the economy. Figure 17 shows how the major stock exchange index (BIST-100), which comprised of 100 industry leading companies in Turkey, react to the variations in the number of coronavirus cases in Turkey.

Figure 17

Fluctuation of BIST-100 with COVID-19 Number of Infected Cases



Note. From World Health Organization (2021) and Investing.com (2021)

The investigation of the link between the number of infected cases and BIST-100 reveals a short-term negative relationship between the two variables. As the effects of the pandemic period on Turkish economy are reviewed, it can be seen that in the beginning of the complete lockdown, the economic activities decreased sharply due to the pandemic. Moreover, many people became unemployed because of the closing of many companies, factories, and many other sectors. For these reasons, many unemployed people, traders, and investors started to consider investing their savings and assets on online working that cannot be affected by curfew and government restrictions,

Chapter 4 findings for stock traders and investors are that they should consider the progression of COVID-19 in Turkey when allocating their portfolio assets among potential instruments, taking into account the impact of the pandemic on these opportunities. Since COVID-19 may impact markets differently, they should always keep an eye on financial and stock market developments. In the following chapter there will be a theoretical and econometrical analysis for the targeted parameters of Turkey.

Chapter 5 consists of two sections, the first section investigates the relationship among Brent oil price and CPI, TIP, TPP, EX, and NG-IP. The second section will analyze the effect of the number of infected cases of coronavirus disease on VIX, Brent-op, and BIST-100.



CHAPTER 5

RESEARCH METHOD

The first part of the thesis will examine the connection between crude oil price shocks and Turkey's economic indicators (CPI, Total Industrial Production Index, Total Petroleum and Other Liquids Production, Nominal Exchange Rate (TRY/USD), and Natural Gas Import Prices). The second part of methodology will provide an examination of the effects of COVID-19 on the prices of crude oil, the volatility of stock prices index (VIX), and the Borsa Istanbul Index (BIST-100). The research's hypotheses are as follows:

Hypothesis 1:

H₀₁: Brent crude oil price has no effect on CPI

H₁₁: Brent crude oil price has a positive effect on CPI

Hypothesis 2:

H₀₂: Brent crude oil price has no effect on Total Industrial Production Index

H₁₂: Brent crude oil price has a negative effect on Total Industrial Production Index

Hypothesis 3:

H₀₃: Brent crude oil price has no effect on exchange rate

H₁₃: Brent crude oil price has a positive effect on exchange rate

Hypothesis 4:

H₀₄: Brent crude oil price has no effect on Total petroleum and natural gas production

H₁₄: Brent crude oil price has positive effect on Total petroleum and natural gas production

Hypothesis 5:

H₀₅: Brent crude oil price has no effect on natural gas import price

H₁₅: Brent crude oil price has a positive effect on natural gas import price

Hypothesis 6:

H₀₆: coronavirus active cases do not affect crude oil prices.

H₁₆: coronavirus active cases affect crude oil prices.

Hypothesis 7:

H₀₇: coronavirus active cases do not affect VIX

H₁₇: coronavirus active cases affect VIX

Hypothesis 8:

H₀₈: coronavirus active cases do not affect BIST-100

H₁₈: coronavirus active cases affect BIST-100

5.1 Background of the Participants

The monthly data of 249 observations for the period between November 2000 and July 2021 will be analyzed using the Eviews program to determine the link between shocks to the price of Brent crude oil and the economic aggregates of Turkey. This will function as the thesis's first section's preface. The analysis uses monthly data for the following indicators:

1. Brent Crude Oil Price (Brent_OP),
2. Exchange Rate (EX),
3. Inflation Rate (CPI),
4. Total Industrial Production Index (TIP),
5. Natural Gas Import Price (NG-IP)
6. Total Petroleum and Other Liquids Production (TPP).

The data were collected from the Federal Reserve Bank of St. Louis (2021), Investing (2021), EIA (2021), and Ychart (2021). The Brent_OP is calculated in USD/barrel for the purpose of research, while the EX is measured per US dollar in national currency (TRY/USD).

Using cointegration test and error correction model (ECM), the thesis examines the relationship between oil price and each economic indicator, including exchange rate, inflation rate, total industrial output index, natural gas import price, and total production of petroleum and other liquids. Additionally, the study will use the Phillips Perron unit root test and the Augmented Dickey Fuller unit root test (ADF, 1981) to examine the attribute of stationarity. Additionally, if the variables are implemented in the same sequence, a cointegration test can be used to see whether they pass together over the long term. Since the

Johansen test (Johansen, 1988) is the only test that can produce reliable findings when more than two cointegration variables are examined, this approach will be used to be on the safe side. After confirming the existence of cointegration between the parameters, the thesis will employ the Autoregressive distributed Lag model (ARDL) to investigate the long-run connection between the variables (Johnston and Dinardo, 1997).

5.1.1 Theory of the model

The economic theory that underpins this investigation is the Marquez model. This model was developed by Jaime Marquez in 1986 as a follow-up to Metzler's (1950) research on the transmission paths of the global oil price. To demonstrate the pathways by which exogenous increases in the price of oil spread over the world, Marquez developed a three-areas and three-commodity models of the global market.

The theory demonstrates how three major groups of countries, developed economies, OPEC economies, and expanding non-OPEC economies, are impacted by fluctuations in oil prices. The primary focus of this examination will be the Turkey theory. According to theory, oil prices have a variety of effects on real income in oil importing countries. The first channel, according to the hypothesis, is its negative influence on consumption, which results in an increase in the CPI. The impact of oil prices on nominal exchange rates and their real purchasing power, which is brought on by an increase in the export prices of manufacturers in developed countries, leads to high import prices and a decline in the foreign real exchange rate in developing economies, has an impact on real income as well. The drop in the real exchange rate has a negative impact on capital formation, capital stock, and manufacturing imports in rising countries outside of OPEC, which slows production growth and raises commodity prices.

The Marquez model forecasts that increasing oil prices will result in a restriction on imports from non-OPEC developing countries using mathematical notations and formulas. In order to account for oil imports in the calculation of foreign exchange resources, it is assumed that the money is utilized to support imported manufactured goods. Equation 5.1 depicts this:

$$M_m = (R + P_r M_r - P_o M_o) / P_m \quad (5.1)$$

Imports by manufacturers will be curtailed if foreign exchange restrictions are put in place, which will limit capital accumulation and production and have a negative influence on GDP growth and inflation. Last but not least, equation 5.2 illustrates how real income and oil prices affect oil imports:

$$M_o = M_o(P_o, Y) \quad (5.2)$$

Where:

- Y: Real income
- O: Oil
- R: Resource transfer
- R: Raw material
- M: Imports
- P: Oil prices
- M: Manufacturing

The study is divided into five models:

- Showed the Relationship Between Brent Oil Prices and The Total Industrial Production Index.
- Showed the Connection Between Brent Oil Prices and Inflation.
- Showed the Connection Between Brent Oil Prices and The Price of Importing Natural Gas.
- Showed the Connection Between Brent Oil Prices and The Total Petroleum and Natural Gas Production.
- Showed the Connection Between Brent Oil Price and Nominal Exchange Rate.

These models' theoretical underpinnings are drawn from Marquize's research (1986). ARDL, developed by Pesaran is used to specify the models. Pesaran's ARDL technique (2001) was used to analyze the relationship between oil prices and the analyzed economic indicators over the short and long terms. The ARDL cointegration methodology has several advantages over other econometric techniques: the underlying variables are not constrained, regardless of whether the variables are integrated of order zero or one. The ARDL-

bounds testing technique avoids this difficulty by not requiring the categorization of variables into Stationarity and non-Stationarity. Furthermore, it may be used with any sample size, little or large. Additionally, our method provides reliable t-statistics and independent long-term estimates of the model even when some of the variables are endogenous.

In order to achieve our objectives of determining how oil prices affect Turkey's total industrial production index, the model will be modified to make real income the focus of the formulas, as suggested in equation 5.2. This is because equation 5.3 states that oil imports depend on both oil prices and real income.

$$Y=f(-P_o, M_o) \quad (5.3)$$

According to equation 5.3, real income grows as a function of oil imports while falling as a function of oil prices. By fitting the regression equations below, the effect of crude oil prices on Turkey's total industrial output index and other indicators will be assessed.

1. The effect of Brent oil price on total industrial production index

$$\Delta TIP_t = \beta_0 + \beta_1 \text{Brent-OP} + \beta_2 \text{NG-IP} + \beta_3 \text{EX} + \beta_4 \text{CPI} + \beta_5 \text{TPP} + \varepsilon_t \quad (5.4)$$

2. The impact of Brent oil prices on the price of importing natural gas

$$\Delta \text{NG-IP}_t = \beta_0 + \beta_1 \text{Brent-OP} + \beta_2 \text{NG-IP} + \beta_3 \text{EX} + \beta_4 \text{CPI} + \beta_5 \text{TPP} + \varepsilon_t \quad (5.5)$$

3. The effect of Brent oil price on nominal exchange rate

$$\Delta \text{EX}_t = \beta_0 + \beta_1 \text{Brent-OP} + \beta_2 \text{NG-IP} + \beta_3 \text{EX} + \beta_4 \text{CPI} + \beta_5 \text{TPP} + \varepsilon_t \quad (5.6)$$

4. The effect of Brent oil price on consumer price index

$$\Delta \text{CPI}_t = \beta_0 + \beta_1 \text{Brent-OP} + \beta_2 \text{NG-IP} + \beta_3 \text{EX} + \beta_4 \text{CPI} + \beta_5 \text{TPP} + \varepsilon_t \quad (5.7)$$

5. The effect of Brent oil price on total petroleum and natural gas production

$$\Delta \text{TPP}_t = \beta_0 + \beta_1 \text{Brent-OP} + \beta_2 \text{NG-IP} + \beta_3 \text{EX} + \beta_4 \text{CPI} + \beta_5 \text{TPP} + \varepsilon_t \quad (5.8)$$

Where:

Δ_t denotes change in economic indicators

β_0 is the intercept of the line on Y-axis.

B denotes the slope co-efficient

Brent-OP denotes Brent oil price.

NG-IP denotes natural gas import price

EX denotes nominal exchange rate

CPI denotes consumer price index

TPP denotes total petroleum and other liquids production

TIP denotes total industrial production index

ε_t is residual term of the model representing all other factors that influence total industrial production index that have not been included in the model.

5.2 Research Design

A time series is a sequence of real numbers, indexed in time. For each instant of time, the value of the quantity studied x_t is called random variable. The set of value x_t is called when t varies random process. A time series is another way that a random process manifests itself. The class of random processes is very large; the time series analysis was therefore initially focused on a particular class of processes. Stationary random processes: these processes are characterized by their statistical properties are stable over time. However, Non-stationary random processes: these processes are characterized by instability of their statistical properties over time.

Cointegration techniques developed by Granger (1981), Engle and Granger (1987), Autoregressive Distributed Lag (ARDL), and bound test of cointegration can be used to determine the long run relationship between non-stationary series as well as reparametrize them to the Error Correction Model (Pesaran, 2001). The estimated result shows the targeted variables' long-run relationship as well as their short-run dynamics. Despite the cointegration technique's versatility in estimating relationships between non-stationary variables and balancing short run dynamics with long run equilibrium, most researchers still use the traditional method of estimation, even when it is obvious that cointegration among the variables under consideration should be tested, otherwise it will estimate a spurious relationship in the long run.

5.2.1 Non-Stationary Random Process

1. *Trend stationary and different stationary processes*³:

In addition to identifying trends (unit root tests), Dickey-Fuller tests can also be used to discover how to make a time series stationary. To do so, two distinguished

³ Johnston, J., Dinardo, J., « Econometric Methods », McGraw-Hill, 1997, 4th edition. pp. 222-223

processors are available: The ST process (Stationary trend) which represents a non-Stationary of deterministic type. DS processes (Difference Stationary) for non-stationary random process (stochastic).

- The ST Process: ST process written $x_t = f_t + \varepsilon_t$ with f_t is a polynomial function of time, linear or nonlinear. The process ST has the Characteristic of linearity, it is written: This process ST is non-stationary because $E(x_t)$ depends on time $\widehat{a}_0$ and $\widehat{a}_1$, the process x_t can be stationary by subtracting according to x_t value in t time; the estimated value $\widehat{a}_0 + \widehat{a}_1 t$. In this type of modeling, the effect of a shock (or multiple random shocks) at a moment t is temporary, the model is deterministic. It is possible to generalize this example to polynomial functions of any degree.
- The DS process: are processes that can be making stationary by using a filter to the differences: $(1-D)^d x_t = \beta + \varepsilon_t$ where ε_t is a stationary process β is a real constant, D is the filter order of differences, and d is the delay operator shift. These processes are often represented using the filter in first differences (d = 1), so the process is called first-order process. It is written as:

$$(1-D)^d x_t = \beta + \varepsilon_t \rightarrow x_t = x_{t-1} + \beta + \varepsilon_t \quad (5.9)$$

The insert of the constant β in the DS process allow defining two different processes: $\beta=0$: the DS process called without drift it is written: $x_t = x_{t-1} + \varepsilon_t$, ε_t is a white noise, this process is called Random Walk Model. It is widely used to analyze the efficiency of financial markets. To make the random walk stationary, we just apply the filter to the first differences:

$$x_t = x_{t-1} + \varepsilon_t \rightarrow (1-D)x_t = \varepsilon_t \quad (5.10)$$

$\beta \neq 0$: The process then called the DS process with drift, it is written $x_t = x_{t-1} + \beta + \varepsilon_t$. The stationarities of this process are carried out using the filter in the first differences:

$$x_t = x_{t-1} + \beta + \varepsilon_t \rightarrow (1-D)x_t = \beta + \varepsilon_t \quad (5.11)$$

In the DS-type process, a shock at given t instant is reflected to infinity on the future values of the series, the shock impact is permanent and is decreasing. The right method to make the data stationary is DS process is ordinary least squares (OLS), for a DS process, the

filter must be used to differences. The random non-stationary $\Leftrightarrow$ the polynomial that characterizes the series has a unit root.

2. Detection of non-stationary (unit root tests)⁴

Unit root tests are numerous. Fuller (1976) and Dickey Fuller's work is cited in this thesis (1979, 1981). The Autoregressive process estimate underlies the parametric Dickey-Fuller tests. These tests are the most used because of their simplicity, but they also suffer from some criticisms. These have led to the development of other unit root tests with those of Phillips and Perron (1988), Perron (1989) and others. We will include the test more common of Dickey-Fuller.

Simple Dickey-Fuller Test⁵: For the series X_t , $t = 1$, Dickey and Fuller (1979) take into account three fundamental models. The three fundamental models are:

Model [1]: model without constant neither deterministic trend:

$$(1 - \Phi_1)\beta)x_t = \beta + \varepsilon_t \quad x_t = \Phi_1 x_{t-1} + \varepsilon_t \quad \text{With } \Phi_1 = R \quad (5.12)$$

Model [2]: model with constant, without deterministic trend:

$$(1 - \Phi_1)\beta)x_t - \mu = \varepsilon_t \quad x_t = \Phi_1 x_{t-1} + c + \varepsilon_t \quad \text{Such as: } c = (1 - \Phi_1)\mu \quad (5.13)$$

Model [3]: model with constant and deterministic trend:

$$(1 - \Phi_1)\beta)x_t - \alpha - \beta_t = \varepsilon_t \quad \rightarrow \quad x_t = \Phi_1 x_{t-1} + c + b_t + \varepsilon_t \quad (5.14)$$

With:

$c = \alpha(1 - \Phi_1)\mu + \Phi_1 \beta$, $b = (1 - \Phi_1)\beta$, B : delay operator and ε_t is the white noise. In each of the three models, we assume that $\varepsilon_t \sim \text{i.i.d.}(0, \sigma^2\varepsilon)$, if $\Phi_1 = 1$, this means that one of the characteristic polynomial roots is equal to 1, which is a presence of a unit root. We compare the alternative hypothesis of no unit root with the null hypothesis of unit root (x_t is integrated of order 1, which led us to believe it is non-stationary), (x_t is integrated of order 0, it means it is stationary). For each of the three models under consideration, let's lay down the null and alternative hypotheses in more detail:

Model [1]: $H_0: \Phi = 1: x_t = x_{t-1} + \varepsilon_t$

$H_1: |\Phi_1| < 1: x_t = \Phi_1 x_{t-1} + \varepsilon_t$

⁴ Johnston, J., Dinardo, J., « Econometric Methods », McGraw-Hill, 1997, 4th edition. pp. 222-223

⁵ Johnston, J., Dinardo, J., « Econometric Methods », McGraw-Hill, 1997, 4th edition. pp. 132-133

Under H_0 : X_t follows a random walk without drift,

H_1 : X_t follows an AR (1).

Model [2]: $H_0: \Phi = 1: x_t = x_{t-1} + \varepsilon_t$

$H_1: |\Phi_1| < 1: x_t = \Phi_1 x_{t-1} + c + \varepsilon_t$

Under H_0 : x_t follows a random walk without drift,

H_1 : x_t follows AR (1) with drift.

Model [3]: $H_0: \Phi = 1: x_t = x_{t-1} + \varepsilon_t$

$H_1: |\Phi_1| < 1: x_t = \Phi_1 x_{t-1} + c + b_t + \varepsilon_t$

Under H_0 : x_t follows a random walk with drift H_1 : x_t is TS with ARMA errors.

The test's basic premise is that the process X_t is non-stationary if the null hypothesis is maintained in all three models.

Augmented -Dickey-Fuller test (ADF)⁶: In previous models used for the Dickey-Fuller simple process ε_t is assumed as a white noise. But the augmented Dickey-Fuller tests take into account the assumption of existence of autocorrelation between errors (this test is used to bleach residuals). The various models used to construct tests statistics are:

$$\text{Model [1]: } \Delta x_t = \rho x_{t-1} + \sum_{i=1}^p \lambda_i \Delta x_{t-i} + \varepsilon_t \quad (5.15)$$

$$\text{Model [2]: } \Delta x_t = \rho x_{t-1} + \sum_{i=1}^p \lambda_i \Delta x_{t-i} + c + \varepsilon_t \quad (5.16)$$

$$\text{Model [3]: } \Delta x_t = \rho x_{t-1} + \sum_{i=1}^p \lambda_i \Delta x_{t-i} + c + bt + \varepsilon_t \quad (5.17)$$

Were

$$\rho = (1 - \phi_1) \text{ and } c = (1 - \Phi_1)\mu, b = (1 - \Phi_1)\beta$$

The fundamental idea behind this technique is to apply the unit root test, then verify through an appropriate test that the model chosen was the best, starting with the most general model (Model [3]). If the model was not the best, the test should be repeated with a different model that is more constrained, and so on, until you get the "correct" model and the best results, of course. Select the number of delay (p) that minimizes the Akaike and Schwarz criteria, so as to make the residuals as a white noise (to whiten the residuals).

⁶ Johnston, J., Dinardo, J., « Econometric Methods », McGraw-Hill, 1997, 4th edition. pp. 132–133

1. ADF Test for model [3]:

We start by testing the unit root using the CV (critical values) associated with the model [3]. The test is as follows:

$$H_0: \rho = 0$$

$$H_1: |\rho| < 1$$

If $t_\varphi < CV$ we reject the null hypothesis of the existence of unit root.

In this case we test the nullity of b by a student test:

- If we reject the hypothesis $b = 0$, this means that the model [3] is the 'right' model to test the unit root, since the presence of a trend is not rejected. So, we conclude that the unit root is rejected, the series type TS is due to the presence of the trend.
- However, if one accepts the hypothesis $b = 0$, the model is not suitable since rejected the presence of a trend. We must repeat the unit root test from model [2], which contains a constant.

$t_\varphi > CV$ not rejects the null hypothesis of existence of unit root.

- Testing the nullity of the coefficient of the trend: If the unit root was not rejected, we use a Fisher statistic, we construct a Fisher test of the joint hypothesis $p = 0$ and $b = 0$. we test also the non-existence of a conditional trend on the presence of a unit root: Test the null hypothesis: $H_0 : (c, b, p) = (c, 0, 0)$ against one of the i different parameters the statistic of this test is constructed as follows:

$$F_3 = \frac{[(SCR_{3,c} - SCR_3/2)]}{SCR_3/(T - K)}$$

With:

- 3 numbers of constraints tested.
- SCR_3 : Sum of squared residuals from the regression of on c, t, x_{t-1} increased terms.
- x_{t-1} : Sum of squared residuals from the regression of Δx_t on just c and augmented terms Δx_{t-1} .

- K: number of explanatory variables constant included in the unconstrained model.
- T: the number of observations used in the regression.

If $F_{3,obs} > F_3$ at threshold $\alpha\%$ we reject H_0 of the nullity of constant conditional coefficient on the presence of a unit root. In this case, the model [3] is the "right" model and the series is of TS Type with drift.

If $F_{3,obs} < F_3$ threshold $\alpha\%$ we accept H_0 of the nullity of the conditional trend coefficient on the presence of a unit root. So, the model [3] is not the "right" model, we must perform the test again to non-stationary in the model [2] including only the constant.

2. ADF test on the model [2]:

Unit root test using the critical values associated at the model [2], the test is as follows:

$$H_0: \rho = 1$$

$$H_1: |\rho| < 1$$

If $t_\phi < CV$ the unit root existence of the null hypothesis has been rejected. We test the nullity of c (constant) by the student test:

If we reject the hypothesis $c = 0$, this means that the model [2] is the 'right' model to test the unit root.

However, if we accept the hypothesis $c = 0$, the model [2] is not suitable because the presence of a constant is rejected. We must repeat the unit root test from model [1], which includes we don't take neither trend nor constant.

If $t_\phi > VC$ not reject the null hypothesis of existence of unit root. Testing the nullity of the coefficient of the constant: If the unit root was not rejected, we construct a Fisher test, of the attached hypothesis $R=0$ and $b=0$. (We test also the nullity of the constant) conditionally on the presence of a unite root. Test the null hypothesis $H_0 : (c, b, p) = (c, 0.0)$ against one of the different parameters; the Statistic of this test is constructed as follows:

$$F_2 = \frac{[(SCR_{2,c} - SCR_2/2)]}{SCR_2/(T - K)}$$

With

- 2 the number of tested constraints
- SCR_2 : sum of squared residuals from the regression of Δx_t on c, x_{t-1} on the increased terms Δx_{t-1}
- $SCR_{2,c}$: Sum of squared residuals from the regression of Δx_t on the augmented terms Δx_{t-1}
- K : number of explanatory variables constant included in the unconstrained model.
- T : the number of observations used in the regression.
- If $F_{2,obs} > F_2$ read in the table, we reject H_0 of the nullity of the conditional constant on the presence of a unit root. In this case, the model [2] is the "right" model and the series x_t is DS type with drift and integrated of order 1, $I(1) + c$.
- If we accept H_0 , the coefficient of the constant is zero, the model [2] is not the "right", and we must perform the test again to non-stationary in the model [1].

3. ADF test on the model [1]:

We Compare the Student statistic t_ϕ from CV tabulated by the Dickey Fuller test:

- If the realization $t_\phi > CV$, we reject the null hypothesis: $H_0: p = 0$ it means: $x_t = x_{t-1} + \varepsilon$ Process is not stationary of DS type without drift.
- If we accept $H_0: p=0 \rightarrow$ process $\Delta x_t = \rho x_{t-1} + \varepsilon$ is the "right" model, the series x_t is $I(0)$ and therefore, it is stationary. The same strategy for the simple DF putting $p = 0$. Unit root tests allow us to know if the series is stationary and what type of non-stationary is it. If the series is non-stationary of DS type, it should be stationary by using the differences. If the series is not stationary of ST type, it should be stationary using regression over the time. The unit root tests are closely related to the theory of cointegration, what we will see in next section.

5.2.2 Vector Autoregressive Model (VAR)

The VAR methodology is to model a group of real time series using an AR (P) with the dynamic model. VAR models used to analyze the effects of policy, that through simulations of random shocks and the variance decomposition of error. However, this analysis is done by the postulant environment economic constant "all things being equal." The VAR is frequently used to predict time series systems and associated variables to study the dynamic impact of random variable systems. The VAR model technique enables removing the requirement for structural models. It is possible to model every endogenous variable in the system as a function of their lagged values.

Definition: x_t a vector of random variables of dimension $n \times 1$ ($X_1, X_2, X_3, \dots, X_n$) and linear function of the past, t over an observation period of length T . The process X_t is generated by a VAR formulation when we assume a symmetrical treatment involved the same number of delays for each component of the suite of variables X_t . The stochastic process X_t , is considered for each element of the vector X observation is assigned to depend on its own past values and the values of all other values in the system. OLS is a suitable estimation method because there is no simultaneity issue provided that only the vector of lag endogenous variables appears on the right side of each equation. By introducing the delay operator (B) the model will be:

$$X_t = (\Phi_1 B + \Phi_2 B^2 + \dots + \Phi_p B^p) X_t + \varepsilon_t (1 - \Phi_1 B - \dots - \Phi_p B^p) X_t = \varepsilon_t \quad (5.18)$$

We obtain:

$$\Phi(B)X_t = \varepsilon_t$$

$$\Phi(B) = 1 - \Phi_1 B - \dots - \Phi_p B^p$$

And in practice the series are generally used in variation, so we can explain the last formula by introducing and differentiates operator 1 as follows:

$$\Phi(B)dX_t = \varepsilon_t \quad dX_t = (1 - B) X_t$$

1. Model specification: Two prediction strategies based on VAR models are possible:

- The first is to construct a model for each variable that is to be expected (variable interest) using the variables containing the most information possible on this variable.
 - The second possibility is to construct a single VAR model containing all the variables that we seek to predict (and possibly other ancillary variables if they are likely to improve predictions).
2. Stationary VAR model⁷: It is assumed that a random vector of n time series X_t is stationary as $X_t = (X_{1t}, X_{2t} \dots X_{nt})$, if its mean m_t and self-covariance matrix $G(t, h)$ are independent of time t . This allows our series follow the same law between period t and $t+h$. VAR model of order p as previously defined in is stationary, if the characteristic polynomial in $(1 - \sum \Phi_i z^i)$ in all the roots of modules greater than 1 (outside the unit circle), in other words: $(1 - \Phi_1 Z - \Phi_2 Z^2 - \dots - \Phi_P Z^P) \neq 0$ for $|Z| \leq 1$, P formula is called "stationary condition".
 3. Features of VAR model: With the use of a VAR model derived in several Features, and note that the VAR representational is generally, it will be used to approximate a stochastic process generated by multivariate series. It does not require of adjustments of judgment. Unfortunately, there is a serious problem that becomes obvious when you look very closely to the properties of our original expectations. This problem refers to the risk of overestimation can happen when too many parameters are estimated with too little data. Because of the risk of overstatement, the unrestricted VAR model is not a good tool for our analysis which leads us to adopt some restrictions that we will see far to avoid a bad prediction. The approach to eliminate this overestimation is to specify values for our coefficients in a situation of very long period have values that are closer to zero, and not do the traditional econometric approach to eliminate all the coefficients that are near to zero. The model used to analyze the effects

⁷ J.D Hamilton time series analyses 1994 Princeton university press Page 258-259

of economic policy, that through simulations of random shocks and the variance decomposition of error. However, this analysis is done by postulating the economic environment constant "all things being equal."

4. VAR model Estimation: The Stationary is an important step in any analysis of a dynamic model, in what follows we present the estimation of a stationary model by the usual methods, considering the stationary VAR model of order 0:

$$x_t = \mu + \sum_{i=1}^p \Phi_1 x_{t-1} + \varepsilon_t \quad (5.19)$$

The Stationary of the multivariate series x_t resulting in the convergence and asymptotic normality of estimates by OLS method, which allows conducting tests on the model parameters and constructing confidence intervals for forecasts. Indeed, this estimation method is the most used of putting the implementation of a simple recursive algorithm for calculation of forecasts.

5. Determination of the number of delays: Two information criteria, the Akaike Information Criterion (AIC) and the Schwartz Criterion (SC), are used to determine the order of a VAR model. In the case of a VAR model these two criteria can be used to determine the order of the P model. Estimating all models for VAR order from zero to h is the method for choosing the order of representation (h being the maximum allowable delay in economic theory by the available data). Calculations for the functions AIC (p) and SC (p) look like this:

$$AIC(p) = \ln \left[\det \left| \Sigma \right| + \frac{2K^2p}{n} \right]$$

$$SC(p) = \ln \left[\det \left| \Sigma \right| + \frac{K^2p \ln(n)}{n} \right]$$

With K = variable number of the system; n: observation number, p: delay number; Σ = variance covariance matrix of the model residuals.

6. Causality⁸: It does not exist in economics a definition of the concept of causality that is accepted by most economists and econometricians. We can mention among the best known, the definitions proposed by Simon (1953), Wald (1954)

⁸ Johnston, J., Dinardo, J., « Econometric Methods », McGraw-Hill, 1997, 4th edition. Pp. 320–322

and more recently Granger (1969). The notion of causality introduced by Granger (1969) is defined in terms of forecasting: a variable X cause's variable Y if X contains information to improve the prediction of Y, this definition was discussed and criticized by Zellner (1979). The main criticism of Zellner against the notion of Granger causality is that it is fully defined in statistical terms and makes no explicit reference to the laws of economic theory. However, we will retain the remainder of this work with the concept of causality defined by Granger, being aware of its limitations, because it has the advantage of being very easily tested in practice and particularly in the context of a VAR model.

Causality test in the Granger method: He proposed the concepts of causality and ergogeneity: Variable Y_{2t} causes Y_{1t} , if the predictability of Y_{1t} is improved when information is relative to Y_{2t} are significant, then the VAR (P) in matrix form:

$$\begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix} = \begin{bmatrix} a_0 \\ b_0 \end{bmatrix} + \begin{bmatrix} a_1^1 & b_1^1 \\ a_1^2 & b_1^2 \end{bmatrix} \begin{bmatrix} y_{1t-1} \\ y_{2t-1} \end{bmatrix} + \begin{bmatrix} a_p^1 & b_p^1 \\ a_p^2 & b_p^2 \end{bmatrix} \begin{bmatrix} y_{1t-p} \\ y_{2t-p} \end{bmatrix} + \dots + \begin{bmatrix} a_p^1 & b_p^1 \\ a_p^2 & b_p^2 \end{bmatrix} \begin{bmatrix} y_{1t-p} \\ y_{2t-p} \end{bmatrix} + \begin{bmatrix} v_{1t} \\ v_{2t} \end{bmatrix}$$

The Granger test is:

- y_{2t} does not cause Y_{1t} : H_0 hypothesis is accepted.

$$H_0: b_1^1 = b_2^1 = \dots = \widehat{b_p} = 0$$

$$H_1: \text{at least: } b_i^2 \neq 0 \forall i = 1, \dots, p$$

- Y_{1t} does not cause Y_{2t} : the H_0 hypothesis is accepted.

$$H_0: a_1^2 = a_2^2 = \dots = a_p^2 = 0$$

$$H_1: \text{at least: } a_i^2 \neq 0 \forall i = 1, \dots, p$$

These tests can be conducted using a Fisher test.

$$F = \frac{[(SCRR - SCRUC)/C]}{SCRUC/(T - K - 1)}$$

With:

T= observations number.

C = number of parameters will be estimated in the VAR.

SCRR: residuals of constrained model.

SCRUC: residuals of unconstrained model

Let us compare to a tabulated Fisher value $F(C, T-K)$

Note. Tests can also be conducted to use a comparison between an unrestricted VAR (UVAR) model and the restricted VAR (VAR R), we calculate the likelihood ratio as follows:

$$L^* = (N-T) \times (\ln |\Sigma_{RAR}| - \ln |\Sigma_{UVAR}|) \rightarrow \chi^2_{(2 \times p)}$$

With:

Σ_{RVAR} : variance covariance matrix of residual constrained model

Σ_{UVAR} : variance covariance matrix of residual unconstrained model

N: observation number.

T: number of parameters of the unconstrained model.

If: $L^* > \chi^2$ read in the table, then we reject the hypothesis of validity of the constraint.

The market responds differently to normal and extraordinary shocks, defying the linear relationship of the VAR model for large shocks. Although the VAR model's linear relationship roughly holds, the features of the VAR estimates are sensitive to the existence of exceptionally big shocks. The distributions from which ordinary and extraordinary shocks are drawn are different. The estimations of the VAR model are typically resistant to outliers.⁹

5.3.2 Cointegration and Error Correction Model

This section will define the notion of integrated series, and the concept of cointegration. There is the sense of Engle and Granger cointegration, Johansen cointegration test and cointegration tests with error correction models. The cointegration theory allows the study of non-stationary series but in a linear combination. It allows specifying long-term stable relationships while analyzing jointly the short-term dynamics of the targeted indicators.

⁹ Katarin and Juselius, The Cointegrated VAR model, UK, OXFORD, 2006, P112

1. The integrated series: We say that a series x_t is integrated of order d , we denote $x_t \rightarrow I(d)$, whether the time to differentiate from the non-stationaries. The most important properties of the integrated series are:
 - i. If the x_t series, is $I(0)$, it is stationary (as in this case it is not affected by a trend).
 - ii. If $x_t \rightarrow I(d)$ so $a + bx_t \rightarrow I(d)$ knowing that a, b are constants, with $b \neq 0$.
 - iii. If $\begin{cases} x_t \rightarrow I(0) \\ y_t \rightarrow I(0) \end{cases}$ so $ax_t + by_t \rightarrow I(0)$

Knowing that a, b are the non-null constants

- iv. If $\begin{cases} x_t \rightarrow I(1) \\ y_t \rightarrow I(1) \end{cases}$ so $z_t = ax_t + by_t \rightarrow I(1)$
 z_t is a non-stationary series since it results from the summation of a series affected by a trend and another stationary series.
- v. If $\begin{cases} x_t \rightarrow I(d_1) \\ y_t \rightarrow I(d_2) \end{cases}$ so $z_t = ax_t + by_t \rightarrow I(\max(d_1, d_2))$

With a, b are non-null constants.

The highest order is typically integrated in all linear combinations of integrated series of different orders. This indicates that over time, the disparity between the series will only widen, and their respective trajectories will be completely dissimilar.

2. Cointegration definition and conditions¹⁰: The treatment of long time series needed to test a possible cointegration (relationship) between variables. Indeed, the risk estimate relationships "misleading" and interpret the results incorrectly is very high, since it is known as regression applied to non-stationary variables can provide interesting results, known in the literature Anglo-Saxon "spurious regressions". The cointegration analysis enables the link between many variables to be determined. Engle and Newbold first proposed this idea in 1974 under the terms "spurious regressions" or "misleading regressions," which were codified by Engle and Granger in 1987 before being advanced by Johansen in 1991 and 1995. So, the solution to the "spurious regressions" is the cointegration.

¹⁰ Johnston, J., Dinardo, J., « Econometric Methods », McGraw-Hill, 1997, 4th edition. pp. 301-303

tion Conditions. Two series x_t and y_t are called Cointegrated if they are assigned of a stochastic trend of the same order of integration d , and a linear combination of these series can be reduced to a series of lower order of integration we have: $x_t \rightarrow I(d)$

$$y_t \rightarrow I(b) \text{ with } \alpha_1 x_t + \alpha_2 y_t \rightarrow I(d-b) \text{ and } d \geq 0, b \geq 0$$

Note. $x_t, y_t \rightarrow [\alpha_1, \alpha_2]$ is the cointegration vector, in the general case with K variables.

We have: $X_{1t} \rightarrow I(d)$

$$X_{2t} \rightarrow I(d)$$

We note $x_t = [X_{1t}, X_{2t}, \dots, X_{kt}]$

$$X_{k,t} \rightarrow I(d)$$

The cointegration vector $\alpha = [\alpha_1, \alpha_2, \dots, \alpha_k]$ of $(k \times 1)$ dimension with $\alpha x_t \rightarrow I(d-b)$, then the k variables are Cointegrated and the cointegration vector is α .

3. Cointegration tests between two variables: We represent the algorithm in two stages of Engle and Granger:

Stage 1: Test the integration order of variables: The series cannot be cointegrated if they are not integrated in the same sequence. The deterministic trend or stochastic type of each variable must therefore be carefully determined using DF and ADF tests, and cointegration is not possible if the examined statistical series are not integrated in the same sequence.

$$x_t \rightarrow I(d) \quad \text{and} \quad y_t \rightarrow I(d)$$

Stage 2: Estimation of the long-term relationship: If the necessary condition is satisfied, we estimate by OLS (Ordinary Least Squares) long-term relationship between variables:

$$y_t = \alpha_1 x_t + \alpha_0 + \varepsilon_t \quad (5.20)$$

When the cointegration relationship is accepted, the residuals e_t resulting from this regression should be stationary:

$$e_t = y_t - \widehat{\alpha}_1 x_t - \widehat{\alpha}_0 = y_t - \widehat{y}_t \quad (5.21)$$

Stationary of the residual is tested using the DF and ADF tests. In all the tests we have:

H_0 : absence of cointegration

H_1 : existence of cointegration

4. Dickey-Fuller and augmented Dickey Fuller tests (DF and ADF): This is to test the existence of a unit root in the estimated residuals $\hat{e}_t$ of the long-term relationship, that $\hat{e}_t = y_t - \hat{a}_1 x_t - \hat{a}_0$, we have:

- DF test: $\Delta \hat{e}_t = \phi \hat{e}_{t-1} + u_t$
- ADF test: $\Delta \hat{e}_t = \phi \hat{e}_{t-1} + \sum_{i=1}^p \Delta \hat{e}_{t-i} + u_t$ in the both cases u_t white noise.

In this case, we can no longer use the tables of Dickey and Fuller. Indeed, the test consists on the estimated residuals from the static relationship and not "real" residuals of the cointegration relationship. Mackinnon (1991) has simulated tables that depend on the number of observation and the numbers of explanatory variables included in the statistical relationship or use the tabulated critical values by Engle (1987)¹¹. We test the null hypothesis H_0 : $\hat{e}_t$ non stationary, it means that $\phi = 0$, the x_t, y_t series are non-Cointegrated. We accept H_0 , where t Student calculated of the coefficient ϕ is greater than the critical value. If the residual is stationary then we can estimate the error correction model.

5. Error correction model (ECM)¹²: Realistic and effective estimates will be obtained by using the ARDL technique to cointegration. The Autoregressive Distributed Lag technique to cointegration facilitates the identification of the cointegration vectors, in contrast to the cointegration procedure devised by Johansen and Juselius (1990). That is, each of the underlying variables may be thought of as a single long-term connection equation. The ARDL model of the cointegration vector is estimated into ECM if one cointegration vector is discovered. The estimation result is used to derive the short-run dynamics and long-run relationships of the variables in a single model. Re-estimation is possible since the ARDL is a dynamic single model equation with the same form as the ECM. A distributed lag model is one in which the explanatory variables are given unconstrained lag in a regression function.

When the variables are non-stationary and Cointegrated, the results of Engle and Granger (1987) show that the correct model specification is to use an error-correction form,

¹¹ Katarin and Juselius, The Cointegrated VAR model, UK, OXFORD, 2006, P112

¹² Johnston, J., Dinardo, J., « Econometric Methods », McGraw-Hill, 1997, 4th edition. pp. 305

which can be reduced to write only stationary variables, and in which it is possible to perform tests on the model parameters. The error correction models are used to correct errors which led to the long-term equilibrium by taking into account the short-term relationship to achieve a predetermined target. The representation of error correction models combines two types of variables:

Variables in level, interpreted as the determinants of long-term equilibrium.

Variables in first difference (stationary) that represent short-term fluctuations.

Statistically, an ECM is a process that can take the form:

$$\Delta y_t = \alpha_1 \Delta x_t + \alpha_2 \Delta(y_{t-1} - \hat{\beta} x_{t-1}) + v_t \quad (5.22)$$

v_t : White noise

- *Estimate the error correction model (ECM) in two steps:*

Step 1: estimation with OLS of the long-term relationship

$$y_t = \hat{\alpha} + \hat{\beta}(x_t) + e_t$$

Step 2: OLS estimation of the relationship of the dynamic model (short term)

$$\Delta y_t = \alpha_1 \Delta x_t + \alpha_2 e_{t-1} + v_t \quad (5.23) \quad ; \alpha_2 < 0$$

The coefficient α_2 (restoring force to balance) must be significantly negative, in the opposite case; it should reject an ECM type specification. Indeed, the error correction mechanism (catch that can tend towards the long-term relationship) would then go in the opposite direction and move away from the long-term target. The two-step procedure leads to a consistent convergent estimation of the model coefficients and the standard deviations of the coefficients can be interpreted in a conventional manner. The estimate of an error correction model is straightforward and only calls for the application of the Ordinary Least Squares (OLS) method.

The fact that the series are Cointegrated and non-stationary raises an estimation problem. The quality of the statistical model R^2 (determination coefficient) high and significant coefficients is due to the fact that the series are non-stationary (because they are Cointegrated), in direct regression of y_t on x_t , the use of this model for predictive purposes is disastrous indeed, the relationship demonstrated by this regression is not real, it is merely a relationship between two trends. The problem is, firstly remove the common relationship

of cointegration (common trend), secondly, to investigate the link between real variables: which is the purpose to use the ECM.

5.3 The ARDL Model of Turkish Economic Fundamentals and Brent Oil Price

The targeted goal of this work is to reduce exposure to price volatility and commercialization challenges, as well as to provide tools that can be used in decision-making for its hedging strategy. This work directly addresses one of the main concerns regarding the relationship between Brent crude oil prices and the economic development of Turkey.

As the study mentioned in the theoretical part of this chapter, Marquez model is the economic theory that supports this research. Jaime Marquez created this model in 1986 as a follow-up to Metzler's (1950) work on worldwide oil price transmission routes. The model revises the work of Gökmenolu et al. (2012) and Husaini and Lean (2021), who looked at the price of oil, the CPI, and the rate of economic exchange. Therefore, our model looks at how the price of oil affects the total industrial output index, total production of petroleum and other liquids, the price of imported natural gas, the CPI, and the nominal exchange rate.

The study will identify the number on integration for each series represented below by applying the ADF test and Phillips-Perron (PP) test. Johnston and Dinardo (1997) theory of cointegration was applied to find out if there is a long-term relation between the oil price (Brent_OP) and other variables. The studied period consists of all series containing monthly observations (249), from Nov (2000) to July (2021).

It is therefore justifiable to apply ARDL model to the economic aggregates with Brent oil price to clarify the interactions of variations of these variables explained by changes in oil prices. In the first part of this section the Stationarity of target variables will be studied. Later in the second part, each step to reach for the best ARDL model will be explained. Then finally, there will be conclusion for our results and recommendations for the government and all economic institutions that concern in evaluating the economic condition of Turkey.

5.3.1 Application of the ARDL Model of Each Economic Parameter

Here an ARDL model is used to describe the impact of Brent oil price fluctuations on the economic development of Turkey. This model was employed in the study to capture the endogeneity and long-run dynamics of the variables as well as the reactions of each economic indicator to changes in the price of Brent oil (Boutahar, 2002). The examination of the effects of Brent oil prices on Turkey's five economic indicators—total industrial output index, CPI, exchange rate, total petroleum and other liquids production, and natural gas import prices—represents the thesis' addition to the existing research. This thesis approaches this subject, by analyzing the effect of Brent oil price on the studied indexes in Turkey from Nov/2000 until July/2021.

The research examines the short and long-term link between Brent oil prices and the economic indexes using monthly data. It is advised to adopt the theory of the ARDL technique put forward by Pesaran (2001) because the series is integrated of order one $I(1)$, 249 monthly observations over a significant time frame are examined in the thesis.

The data for total industrial production index, CPI, and Brent oil price were collected from the Federal Reserve Bank of St. Louis (2021), and the data of the exchange rate were collected from (Investing, 2021). Other data of natural gas import price and total petroleum and other liquid production were collected from Ychart website (2021) and EIA (2021), respectively. Table 7 is a descriptive summary for the targeted parameters.

Table 7

Descriptive Summary Statistics (Nov 2000 - July 2021)

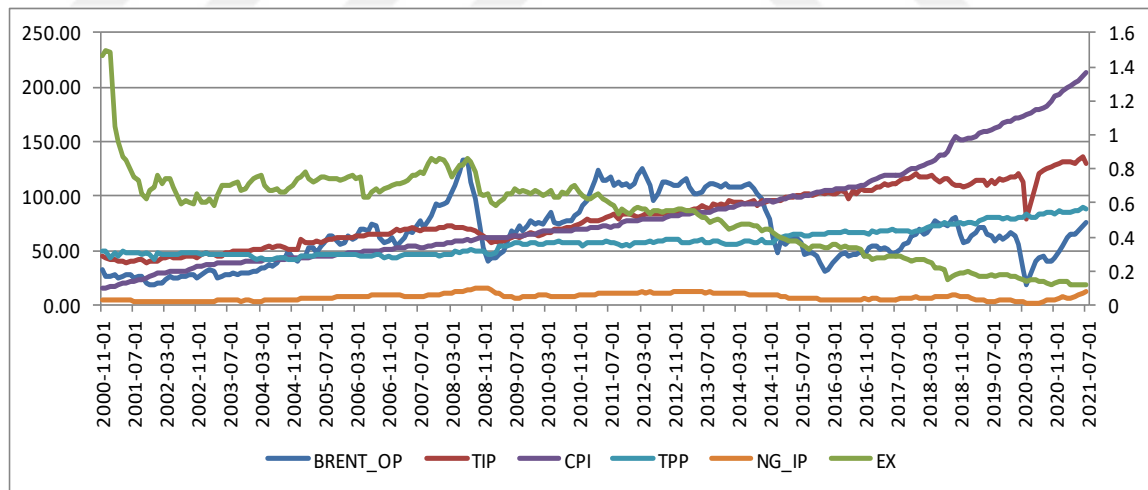
	Brent ⁱⁱ	CPI ⁱ	EX ⁱ	NG_IP ⁱ	TIP ⁱ	TPP ⁱ
Mean	64.95	83.49	0.536	7.291	80.40	57.87
Maximum	132.7	213.8	1.491	15.93	135.5	90.41
Minimum	18.38	15.82	0.114	1.575	38.89	42.09
Std. Dev.	29.07	46.86	0.244	3.138	26.06	12.41

Note. (i) monthly observations reported at Turkey level; (ii) Brent refers to oil prices, created by using Eviews

As can be seen in Figure 18, Brent oil price and CPI are moving together in the long run. Brent oil prices faced two crises, a financial crisis in 2008 and Saudi Arabia oil war with COVID-19 crisis in 2020. Moreover, CPI increased by 20% recently in 2021. Through the studied period total industrial production index have an upward trend with downturns followed by the increase in crude oil prices and other financial and health crisis as COVID-19 pandemic. Turkish currency faced a decrease trend in nominal exchange rate of Turkish Lira which leads to reduce its real purchasing power. During the studied period Turkish lira was depreciated against US dollar sharply in 2018 and 2021. TPP has an upward trend with the increase in crude oil price in the long run, furthermore, natural gas import price is moving together with Brent oil prices, with slightly downturns in extraordinary periods.

Figure 18

Evolution of Brent Oil Price with Economic Indicators of Turkey



Note. From Investing.com (2021), Ychart.com (2021), Bloomberg.com (2021), and Federal Reserve Bank of Saint Louis (2021), accessed on Aug 20 2021.

Autoregressive Distributed Lag Model Estimation Procedure:

According to the Augmented Dickey Fuller and Phillips-Perron unit root tests, the following series are of order one I (1). Brent oil price, CPI, EX, NG_IP, TPP, and TIP are

all significant at 5% significant level at the first difference (Review Appendix A). Table 8 displays the results of the two tests.

Table 8

Unit Root Test for Each Economic Indicator¹³

	Brent	CPI	EX	NG_IP	TIP	TPP
ADF level	-2.6427	5.0849	-5.2117	-2.2307	-4.8761	-2.4957
ADF first I (1)	-10.490*	-4.5603*	-13.036*	-5.2476*	-11.729*	-20.776*
Phillips-Perron level	-2.0252	5.9016	-5.2784	-2.0271	-4.7415	-2.0233
Phillips-Perron I (1)	-9.9601*	-9.9258*	-13.173*	-11.300*	-20.237*	-22.621*

Note. * t-statistic means significance at 1%, 5% and 10%; created by using Eviews 10

1. Lag Selection of ARDL Model

The model with the lowest value for both the information criterion, AIC and SIC, is chosen, just like in Table 9. The following table gives the values of the two criteria for the different five models. ARDL models are devoid of residual correlation, according to Pesaran (2001). As a result, there are no endogeneity difficulties with proper lag selection. As can be seen in Table 9, CPI of 6 lags, TTP of 4 lags, NG_IP of 5 lags, and TPP, EX are of 2 lags.

¹³ Study of the Stationarity of each Economic Indicator were Explained in Appendix A

Table 9*Lag Structure Criteria Selection of ARDL Model*

Model	Number of lags	Lag Structure Criteria	
		AIC	SIC
CPI	P = 6	2.418670*	2.592187
TIP	P = 4	5.196410*	5.312354
NG_IP	P = 5	1.435814*	1.586357
TPP	P = 2	3.366403*	3.476312
EX	P = 2	-4.567534*	-4.456852

Note. AIC information criterion using VAR model estimate is the foundation for selecting the best lag, created by using Eviews 10

The ARDL model is employed to estimate the link between Brent crude oil prices, CPI, TIP, EX, NG_IP, and, TPP. The model probably applies for both the I (0) and I (1) series. Our model is based on the theory of Pesaran (2001), which uses an error correction modulation and a linear transformation to incorporate short-run changes into the long-run equilibrium. These are the five ARDL Models:

i. CPI ARDL Model:

$$\begin{aligned} \Delta CPI_t = & c + p_1 Brent_{t-1} + p_2 CPI_{t-1} + p_3 TIP_{t-1} + p_4 EX_{t-1} + p_5 NG_IP_{t-1} + p_6 TPP_{t-1} + \\ & \sum_{i=1}^6 \lambda_i \Delta Brent_{t-i} + \sum_{i=1}^6 \lambda_i \Delta CPI_{t-i} + \sum_{i=1}^6 \lambda_i \Delta TIP_{t-i} + \sum_{i=1}^6 \lambda_i \Delta EX_{t-i} + \sum_{i=1}^6 \lambda_i \Delta NG_IP_{t-i} + \\ & \sum_{i=1}^6 \lambda_i \Delta TPP_{t-i} + \theta ECT_{t-i} + \varepsilon_t \end{aligned} \quad (5.24)$$

ii. TIP ARDL Model:

$$\begin{aligned} \Delta TIP_t = & c + p_1 Brent_{t-1} + p_2 CPI_{t-1} + p_3 TIP_{t-1} + p_4 EX_{t-1} + p_5 NG_IP_{t-1} + p_6 TPP_{t-1} + \\ & \sum_{i=1}^4 \lambda_i \Delta Brent_{t-i} + \sum_{i=1}^4 \lambda_i \Delta CPI_{t-i} + \sum_{i=1}^4 \lambda_i \Delta TIP_{t-i} + \sum_{i=1}^4 \lambda_i \Delta EX_{t-i} + \sum_{i=1}^4 \lambda_i \Delta NG_IP_{t-i} + \\ & \sum_{i=1}^4 \lambda_i \Delta TPP_{t-i} + \theta ECT_{t-i} + \varepsilon_t \end{aligned} \quad (5.25)$$

iii. EX ARDL Model:

$$\begin{aligned} \Delta EX_t = & c + p_1 Brent_{t-1} + p_2 CPI_{t-1} + p_3 TIP_{t-1} + p_4 EX_{t-1} + p_5 NG_IP_{t-1} + p_6 TPP_{t-1} + \\ & \sum_{i=1}^2 \lambda_i \Delta Brent_{t-i} + \sum_{i=1}^2 \lambda_i \Delta CPI_{t-i} + \sum_{i=1}^2 \lambda_i \Delta TIP_{t-i} + \sum_{i=1}^2 \lambda_i \Delta EX_{t-i} + \sum_{i=1}^2 \lambda_i \Delta NG_IP_{t-i} + \\ & \sum_{i=1}^2 \lambda_i \Delta TPP_{t-i} + \theta ECT_{t-i} + \varepsilon_t \end{aligned} \quad (5.26)$$

iv. NG_IP ARDL Model:

$$\begin{aligned} \Delta NG_IP_t = & c + p_1 Brent_{t-1} + p_2 CPI_{t-1} + p_3 TIP_{t-1} + p_4 EX_{t-1} + p_5 NG_IP_{t-1} + p_6 TPP_{t-1} + \\ & \sum_{i=1}^5 \lambda_i \Delta Brent_{t-i} + \sum_{i=1}^5 \lambda_i \Delta CPI_{t-i} + \sum_{i=1}^5 \lambda_i \Delta TIP_{t-i} + \sum_{i=1}^5 \lambda_i \Delta EX_{t-i} + \sum_{i=1}^5 \lambda_i \Delta NG_IP_{t-i} + \\ & \sum_{i=1}^5 \lambda_i \Delta TPP_{t-i} + \theta ECT_{t-i} + \varepsilon_t \end{aligned} \quad (5.27)$$

v. TPP ARDL Model:

$$\begin{aligned} \Delta TPP_t = & c + p_1 Brent_{t-1} + p_2 CPI_{t-1} + p_3 TIP_{t-1} + p_4 EX_{t-1} + p_5 NG_IP_{t-1} + p_6 TPP_{t-1} + \\ & \sum_{i=1}^2 \lambda_i \Delta Brent_{t-i} + \sum_{i=1}^2 \lambda_i \Delta CPI_{t-i} + \sum_{i=1}^2 \lambda_i \Delta TIP_{t-i} + \sum_{i=1}^2 \lambda_i \Delta EX_{t-i} + \sum_{i=1}^2 \lambda_i \Delta NG_IP_{t-i} + \\ & \sum_{i=1}^2 \lambda_i \Delta TPP_{t-i} + \theta ECT_{t-i} + \varepsilon_t \end{aligned} \quad (5.28)$$

Where:

- The intercept and error term are denoted by c and ε , correspondingly.
- Short-run terms are represented by Δ , whilst long-run terms are represented by p -terms.
- The largest number of lags is i .
- The adjustment speed parameter is θ , which stands for the error correction term (ECT), should be significant and negatively skewed in order to support the long-term relationship. The residual that needs to be taken out of the long run model is ECT.

F-statistic of Wald and Bound tests are used to confirm the presence of long-run correlation. To assess for residual serial correlation, a set of post-estimation tests are conducted (Breusch-Godfrey LM test) and CUSUM test check the stability of the models.

2. Testing for Cointegration Relationship

The first stage in determining the best ARDL model is to determine whether a long-run connection exists because the Wald test assumes that the null hypothesis is $p_1 = p_2 = p_3 = p_4 = p_5 = p_6 = 0$. Additionally, bound tests were employed in the thesis, which assumed a lower bound for the $I(0)$ series and an upper bound for the $I(1)$ series, with critical values determined from Narayan's work (2005).

In Table 10, the first test to indicate a long run relationship is the Wald test, that showed a cointegration for all five models: CPI, EX, NG_IP, TPP, and TIP with 0.0000 probabilities at 5% significant level. Moreover, long run form and bound test was used to

reach for cointegration between the targeted parameters. The F-statistic suggests a cointegration connection.

A long-run association between Brent oil prices, inflation rate (CPI), exchange rate, natural gas import price, total petroleum and other liquid production, and total industrial production index in the five models with CPI, EX, NG_IP, TIP, and TPP as the dependent variables are detected and these results are consistent with Wald test results. The bound tests for all variables, with the exception of TIP, which was accepted at a 10% significant level, show that a cointegration connection exists at a 5% significance level.

Table 10

Robustness Analysis for Long-Run relationship

Wald test				
Model specification	F-statistic	Probability		Conclusion
CPI	F _{CPI} = 1360.7	0.000		Cointegration
EX	F _{EX} = 249.89	0.000		Cointegration
NG_IP	F _{NG_IP} = 129.38	0.000		Cointegration
TIP	F _{TIP} = 524.49	0.000		Cointegration
TPP	F _{TPP} = 879.40	0.000		Cointegration
Bound test				
Model specification	F-statistic	Critical values		Conclusion
		Lower bound I (0)	Upper bound I (1)	
CPI	F _{CPI} = 18.951	2.62	3.79	Cointegration
EX	F _{EX} = 10.601	2.62	3.79	Cointegration
NG_IP	F _{NG_IP} = 9.77	2.62	3.79	Cointegration
TIP	F _{TIP} = 2.5444	2.26	3.35	Cointegration
TPP	F _{TPP} = 4.8021	2.62	3.79	Cointegration

Note. (i) Probability at 5% significance level, (ii) TIP at 10% significant level created by using Eviews 10

3. Autoregressive Distributed Lag Model (ARDL) Estimation

The five ARDL models are estimated in the third stage (Table 11). Brent oil price has a positive impact on CPI of Turkey. An upward trend in inflation was observed in model 1 by the positive long-run correlation among Brent oil prices, EX, NG_IP, TIP, and TPP, which can be estimated by an ECM Model for a level equilibrium relationship. The causal effect direction between Brent oil price and CPI was observed by Johansen cointegration test by the normalized cointegration coefficients opposite sign (-0.196842). In Model 1, the long run relationship can be approved by looking at the lag of the error correction term (ECT1) probability 0.0000 at 5% significant level with a negative sign for its coefficient (-0.858887). However, for the joint significance of the short run lagged variables, the lags of CPI and EX were all with F statistics higher than 1.96 and were jointly significant, which are approved by Wald test. Moreover, the positive direction of the causal effect of the exchange rate on CPI was observed by Johansen cointegration test with a negative sign of its coefficient (-192.7611). ECM Model for CPI is:

$$\begin{aligned} \Delta CPI_t = & 1.25652751\Delta CPI_{t-1} - 0.45349160\Delta CPI_{t-2} + 0.33076479\Delta CPI_{t-3} - 0.31386299\Delta CPI_{t-4} + \\ & 0.148162802\Delta CPI_{t-5} + 0.0610112103\Delta CPI_{t-6} - 5.14314505\Delta EX_{t-1} - 1.35324865\Delta EX_{t-2} + \\ & 0.728841702\Delta EX_{t-3} - 1.1239078024\Delta EX_{t-4} - 2.677958196\Delta EX_{t-5} - 0.25446029\Delta EX_{t-6} - \\ & 0.85888689ECT1_{t-1} + \varepsilon_t \end{aligned} \quad (5.29)$$

Where, ECT1 is the adjusted speed for long run equilibrium, which means that the deviations of consumer price index need 8.58% speed toward long run equilibrium. Table 11 analyze model 1 of CPI.

Table 11*Estimation of Model 1: CPI ARDL Specification*

Model 1: Consumer Price Index (CPI)		
Long-Run Equation		
	coefficient	Prob.
CPI (-1)	1.009626	0.0000
BRENT_OP (-1)	-0.004882	0.1974
EX (-1)	-0.333691	0.4905
NG_IP (-1)	0.013080	0.7046
TIP (-1)	-0.006696	0.3488
TPP (-1)	0.016309	0.2086
Short-Run Equation		
ECM Model (long-run)		
D (CPI (-1))	1.256528	0.0000*
D (CPI (-2))	-0.453492	0.0000*
D (CPI (-3))	0.330765	0.0001*
D (CPI (-4))	-0.313863	0.0004*
D (CPI (-5))	0.148163	0.0746*
D (CPI (-6))	0.061011	0.4020*
D (EX (-1))	-5.143145	0.0142*
D (EX (-2))	-1.353249	0.5202*
D (EX (-3))	0.728842	0.7304*
D (EX (-4))	-1.123908	0.4500*
D (EX (-5))	-2.677958	0.0709*
D (EX (-6))	-0.254460	0.8586*
ECT1(-1)	-0.858887**	0.0000**
Test		
Serial correlation	NO	
Stability	YES	

Notes: (i) ** denotes the long-term relationship's significance of the error correction term at 5%.; (ii) * Wald test for the variable lags' combined significance in the short-run relationship; (iii) For serial correlation, the

Breusch-Godfrey LM test is utilized; (iv) CUSUM tests are performed to assess stability; (v) The residuals will be extracted using long-run equations to build the ECT.

The Breusch-Godfrey LM test was used in the thesis to examine the model serial correlation. The test resulted in a higher than 5% significant level F statistic of 1.315451 and probability of 0.2518. So, it is impossible to rule out the null hypothesis that there is no serial association. The study also used the Cusum test to assess the CPI model's stability¹⁴.

The coefficient of the lagged ECT for model 2 of the total industrial production index (TIP) with a probability of 0.0458 implies that the coefficient is significant at 5% level with a negative sign (-0.634615). Brent oil price has a rather negative impact on TIP index of Turkey in the long run and the short run. For that reason, a downward trend in TIP was observed by the negative long-run correlation among Brent oil prices, EX, NG_IP, TIP, and TPP in Model 2, which can be estimated by an ECM Model for a level equilibrium relationship. The causal effect direction between Brent oil price and TIP index was observed by Johansen cointegration test by the normalized cointegration coefficients opposite sign (0.207837). The lags of Brent and TIP, on the other hand, all had F values higher than 1.96 and were jointly significant for the short run lagged variables, which is supported by the Wald test. ECM Model 2 for TIP index is:

$$\begin{aligned} \Delta TIP_t = & 0.17564\Delta Brent_{op_{t-1}} - 0.024395\Delta Brent_{op_{t-2}} + 0.0058\Delta Brent_{op_{t-3}} - \\ & 0.071251\Delta Brent_{op_{t-4}} + 0.440080\Delta TIP_{t-1} - 0.171496\Delta TIP_{t-2} - 0.149775\Delta TIP_{t-3} - \\ & 0.071130\Delta TIP_{t-4} - 0.634615ECT2_{t-1} + \varepsilon_t \end{aligned} \quad (5.30)$$

Where, ECT2 is the adjusted speed for long run equilibrium, which means that the deviations of total industrial production index need 6.34% speed toward long run equilibrium. Table 12 analyze model 2 of total industrial production (TIP) index.

¹⁴ Appendix B : Figure 2.1 illustrates how the CPI ARDL model is stable by laying between the 15 percent boundaries.

Table 12*Estimation of Model 2: TIP ARDL*

Model 2: Total Industrial Production Index (TIP)		
Long-Run Equation		
	Coefficient	Prob.
CPI (-1)	0.040930	0.0886
BRENT_OP (-1)	0.026715	0.0582
EX (-1)	-2.349962	0.2635
NG_IP (-1)	-0.177190	0.1684
TIP (-1)	0.913637	0.0000
TPP (-1)	-0.028812	0.6918
Short-Run Equation		
ECM Model(long-run)		
D (BRENT__OP (-1))	0.175644	0.0000
D (BRENT__OP (-2))	-0.024395	0.5771
D (BRENT__OP (-3))	0.005808	0.8928
D (BRENT__OP (-4))	-0.071251	0.0933
D (TIP (-1))	0.440080	0.1608
D (TIP (-2))	-0.171496	0.0147
D (TIP (-3))	-0.149775	0.0298
D (TIP (-4))	-0.071130	0.2935
ECT2(-1)	-0.634615	0.0458
Test		
Serial correlation		NO
Stability		YES

To test the model serial correlation, the thesis applied Breusch-Godfrey LM test. The test showed an F statistic of 1.113106 and probability of 0.3304 which is higher than 5% significant level. This makes it impossible to rule out the null hypothesis that there is no serial association. Additionally, the study used the Cusum test to assess the stability of the TIP model¹⁵.

Brent oil price has a rather positive impact on natural gas import prices in the long run, whereas the effect is insignificant in the short run. For that reason, an upward trend in natural gas import price was observed by the positive long-run correlation among Brent oil prices, EX, NG_IP, TIP, and TPP in Model 3, which can be estimated by an ECM Model for a level equilibrium relationship. The causal effect direction between Brent oil price and NG_IP was observed by Johansen cointegration test by the normalized cointegration coefficients opposite sign (-0.060675). In Model 3, the long run relationship can be approved by looking at the lag of the error correction term (ECT3) probability 0.0006 at 5% significant level with a negative sign for its coefficient (-0.723058). However, the lags of EX were all jointly significant and had F values higher than 1.96 for the short run lagged values, which is supported by the Wald test. Moreover, the positive ceteris paribus¹⁶ effect of the exchange rate on NG_IP was observed by Johansen cointegration test with the opposite negative sign of its coefficient (-82.01635). ECM Model 3 for NG_IP is:

$$\Delta NG_IP_t = -0.631767\Delta EX_{t-1} - 1.496637\Delta EX_{t-2} + 0.42682\Delta EX_{t-3} + 0.73413\Delta EX_{t-4} - 0.437423\Delta EX_{t-5} - 0.723058ECT3_{t-1} + \varepsilon_t \quad (5.31)$$

Where, ECT3 is the adjusted speed for long run equilibrium, which means that the deviations of natural gas import price needs 7.23% speed toward long run equilibrium. Table 13 analyze model 3 of NG_IP.

¹⁵ Appendix B : Figure 31 illustrates how the TIP ARDL model is stable by laying between the 15 percent boundaries.

¹⁶ Ceteris Paribus Effect: means with other conditions remaining the same; other things being equal.

Table 13*Estimation of Model 3: NG_IP ARDL Specification*

Model 3: Natural Gas Import Price (NG_IP)		
Long-Run Equation		
	coefficient	Prob.
CPI (-1)	0.007412	0.0599
BRENT_OP (-1)	0.010754	0.0000
EX (-1)	1.248453	0.0003
NG_IP (-1)	0.885671	0.0000
TIP (-1)	0.004237	0.3456
TPP (-1)	-0.015556	0.1920
Short-Run Equation		
ECM Model (long-run)		
D (EX (-1))	-0.631767	0.6228
D (EX (-2))	-1.496637	0.2622
D (EX (-3))	0.426829	0.6464
D (EX (-4))	0.734134	0.4286
D (EX (-5))	-0.437423	0.6237
ECT3(-1)	-0.723058	0.0006
Test		
Serial correlation	NO	
Stability	YES	

To test the model serial correlation, the thesis applied Breusch-Godfrey LM test. The test showed an F statistic of 2.521168 and probability of 0.0828 which is higher than

5% significant level. In this way the null hypothesis of no serial correlation cannot be rejected. Moreover, for testing the stability of NG_IP model, the study applied Cusum test¹⁷.

According to model 4, the long-term relationship between the price of Brent oil and Turkey's total output of petroleum and other liquids is positive, but the short-term impact is negligible. For that reason, an upward trend in TPP was observed by the positive long-run correlation among Brent oil prices, EX, NG_IP, TIP, and TPP in Model 4, which can be estimated by an ECM Model for a level equilibrium relationship. The causal effect direction between Brent oil price and TPP was observed by Johansen cointegration test by the normalized cointegration coefficients opposite sign (-0.031379). In Model 4, the long run relationship can be approved by looking at the lag of the error correction term (ECT4) probability 0.0000 at 5% significant level with a negative sign for its coefficient (-0.338062). ECM Model 4 for TPP is:

$$\Delta TPP_t = -0.338062ECT4_{t-1} + \varepsilon_t \quad (5.32)$$

Where, ECT4 is the adjusted speed for long run equilibrium, which means that the deviations of TPP needs 3.38% speed toward long run equilibrium. Table 14 analyzes model 4 of TPP:

¹⁷ Appendix B : Figure 32 illustrates how the NG-IP ARDL model is stable by laying between the 15 percent boundaries.

Table 14*Estimation of Model 4: TPP ARDL Specification*

Model 4: Total Petroleum and Other Liquid Production (TPP)		
Long-Run Equation		
	coefficient	Prob.
CPI (-1)	0.034682	0.0009
BRENT_OP (-1)	0.000282	0.9627
EX (-1)	0.039111	0.9654
NG_IP (-1)	-0.041603	0.4506
TIP (-1)	0.006163	0.6005
TPP (-1)	0.865900	0.0000
Short-Run Equation		
ECM Model (long-run)		
ECT4(-1)	-0.338062	0.0000
Test		
Serial correlation	NO	
Stability	YES	

To test the model serial correlation, the thesis applied Breusch-Godfrey LM test. The test showed an F statistic of 1.163524 and probability of 0.2818 which is higher than 5% significant level. This makes it impossible to rule out the null hypothesis that there is no serial association. Additionally, the study used the Cusum test to assess the stability of the TPP model¹⁸.

In model 5, both the long-term and short-term effects of the price of Brent oil are favorable for the exchange rate (TRY/USD). For that reason, a downward trend in EX of Turkish lira was observed by the positive long-run shocks of Brent oil prices, which can

¹⁸ Appendix B : Figure 33 illustrates how the TPP ARDL model is stable by laying between the 15 percent boundaries.

be estimated by an ECM Model for a level equilibrium relationship. As Brent oil prices increase, the Turkish lira is depreciated against the US dollar, which means that the exchange rate will increase.

Turkey, a country that imports oil, will gain from the local currency's decline versus the dollar by increasing its exports. The depreciation of the Turkish lira will lead to reduction in imports, as it will become more expensive for traders and investors. However, the net effect on the real output growth of Turkey will be negative as an oil importing country. The causal effect direction between Brent oil price and EX (TRY/USD) was observed by Johansen cointegration test by the normalized cointegration coefficients opposite sign (-0.000333).

In Model 5, the long run relationship can be approved by looking at the lag of the error correction term (ECT5) probability 0.0000 at 5% significant level with a negative sign for its coefficient (-1.944663). Additionally, the Wald test demonstrates a significant short-run link between the lags of the exchange rate and the price of Brent oil. The estimated model approved that by F statistics= 5.515898 with Prob. of 0.0046 for the lagged Brent oil prices and an F statistic=80.13848 with Prob. of 0.0000 for the lags of EX which is less than 5% significant level. ECM Model 5 for EX is:

$$\Delta EX_t = 0.000966\Delta Brent_{op_{t-1}} + 0.000376\Delta Brent_{op_{t-2}} + 1.743502\Delta EX_{t-1} - 0.028286\Delta EX_{t-2} - 1.944663ECT5_{t-1} + \varepsilon_t \quad (5.33)$$

Where, ECT5 is the adjusted speed for long run equilibrium, which means that the deviations of EX need 1.94% speed toward long run equilibrium.

The Breusch-Godfrey LM test was used in the thesis to examine the model serial correlation. The test resulted in a F statistic of 42.74622 and a probability of 0.3621, both of which are higher than the 5% level of significance. So, it is impossible to exclude out the null hypothesis that there is no serial association. Additionally, the study used the Cusum test to evaluate the stability of the EX-model¹⁹. Table 15 analyzes model 4 of EX.

¹⁹ Appendix B : Figure 34 illustrates how the EX ARDL model is stable by laying between the 15 percent boundaries.

Table 15*Estimation of Model 5: EX (TRY/USD) ARDL Specification*

Model 5: Exchange Rate (TRY/USD)		
Long-Run Equation		
	coefficient	Prob.
CPI (-1)	0.000192	0.4520
BRENT_OP (-1)	0.000353	0.0189
EX (-1)	0.853223	0.0000
NG_IP (-1)	-0.001216	0.3735
TIP (-1)	-0.000700	0.0169
TPP (-1)	-0.001869	0.0162
Short-Run Equation		
ECM Model (long-run)		
D (BRENT__OP (-1))	0.000966	0.0083
D (BRENT__OP (-2))	0.000376	0.3052
D (EX (-1))	1.743502	0.0000
D (EX (-2))	-0.028286	0.5850
ECT5(-1)	-1.944663	0.0000
Test		
Serial correlation	NO	
Stability	YES	

5.3.2 Econometrical Results of Brent Oil Price and Economic Indicators

An ARDL Model was used to analyze the effects of Brent crude oil price shocks on Turkey's economic indicators from November 2000 to July 2021. Wald and Bound cointegration tests were also used to examine the relationship between Brent oil price shocks and the CPI inflation rate, total industrial production index (since Turkish GDP

monthly data is unavailable), exchange rate (TRY/USD), and Turkey's natural gas import prices (estimated by European natural gas import prices because Turkish data is not available). The ECM model calculated estimates for all five models. The results of the ADF test and Phillips-Perron (PP) unit root test show that all the variables under consideration are integrated of order one. The results indicate a long-term relationship between these variables, and the Granger causality test demonstrates a one-way relationship between the price of Brent oil and all examined economic indices. It is consistent with other studies by Hamilton (1983), Husaini and Lean (2021), Ewing and Thompson (2007), and Zhao et al. (2016) showing sudden changes in the price of crude oil have an effect on economic development.

5.4 Research Method of COVID-19 Effect on Energy and Stock Market

This part of chapter 5 will analyze the research method of the relationship among COVID-19 and stock and energy markets. Furthermore, the following parts will analyze and explain the parameters and estimation the significant ARDL model to analyze the parameters. Then, the thesis will explain the results econometrically.

5.4.1 Background of participants

The thesis' second section uses daily data to look at the relationship between COVID-19, BRENT, VIX, and BIST-100 over the short/long term. Our series is integrated of order I (1), which suggests using Pesaran theory of the ARDL technique (2001). Albulescu (2020a) ARDL Model, which was the first to address the COVID-19 effects on stock and energy market literatures, served as the foundation this work. However, neither of these studies addresses the current predicament created by COVID-19 dilemma after July 2020. This study, which spans a long period of 284 daily observations and includes some events like curfew, lockdown, vaccinations, social distancing restrictions and regulations with periods of normal life and economic activities, addresses this issue by looking at the effects of coronavirus numbers on BRENT, VIX, and BIST-100.

5.4.2 Selection of the participants

The following are the study's methodology steps: The data for this analysis was gathered from various data sources as the first step in the methodology. The data for COVID-19 number of infected cases were collected from WHO (2021), and other data

were extracted from the Federal Reserve Bank of St. Louis (2021), Bloomberg (2021), and Investing (2021). Since data for certain factors, such as BIST-100, VIX, and Brent oil price, could not be accessed for weekends, only weekday data is used. As a result, the weekend and official holidays are not included in the study.

The second move was to merge all of the datasets to create a single combined dataset that could be analyzed. In the third phase, the datasets were examined to determine whether COVID-19 had any short- and long-term effects on the BIST-100 index, VIX, and Brent Oil Price. In the fourth stage, an Autoregressive Distributed Lag Model was applied to all datasets (ARDL). The methodology's final conclusion assessed the results from the epidemic times.

5.4.3 Research design of stock and energy market parameters

An ARDL model is used to discuss how COVID-19 infections affect the energy and stock markets. This model was used in the study to capture the endogeneity, long-run dynamics, and responses of the variables to the increase in COVID-19 infection cases, as well as the responses of oil prices and market stock returns. The assessment of COVID-19's effects on Brent oil prices, Borsa Istanbul Index (BIST-100), and the volatility of stock price index (VIX) is the thesis' contribution to the existing literature.

This thesis approaches this subject, by analyzing the effect of COVID-19 on the studied indexes in Turkey for all periods of the pandemic, which is from the first infected case in Turkey at 11 March/2020 until the beginning of vaccination in 12 April/2021 (WHO, 2021). Using daily data, the study evaluates the relationship between COVID-19, oil prices, VIX, and BIST-100 over the short- and long-term. The descriptive statistics for the series used in this study are displayed in Table 16.

Table 16*Descriptive Summary Statistics (11 March 2020 - 12 April 2021)*

	BRENT ⁱⁱ	COVID-19 ⁱ	VIX Index	BIST-100
MIN	9.12	0	16.69	842.46
MAX	69.95	55941	82.69	1570.42
MEAN	43.84	7836.97	29.15	1222.02
ST. DEV	13.26	11476.77	10.99	205.49

Note. (i) The daily instances reported in Turkey are referred to as COVID-19; (ii) Brent is a term used to describe oil prices, created by using Eviews 10

In this part the thesis will analyze the relationship between COVID-19 infected cases with prices of Brent crude oil, BIST-100 Index, and VIX Index. First, test the Stationarity of the series, and then create an ARDL model to explain the correlation between COVID-19 and the target indicators in the short and long run.

1. Study of the Stationarity of COVID-19 and stock and energy indicators

According to the Augmented Dickey Fuller and Phillips-Perron unit root tests, the following series are of order one I (1). At the first difference, the Brent oil price, VIX, COVID-19, and BIST-100 are all statistically significant at the 5% level²⁰. Table 17 lists the outcomes of the two tests. `

²⁰ Appendix C : Study of the Stationarity of COVID-19 and Stock and Energy Indicators

Table 17*Unit Root Tests of Brent/VIX/BIST-100/COVID-19²¹*

	BRENT	COVID-19	VIX Index	BIST-100 Index
<i>ADF level</i>	-2.6859	-1.5406	-3.1046	-1.6416
<i>ADF first I (1)</i>	-8.3685*	-4.5897**	-5.8196***	-7.2358***
<i>Phillips-Perron level</i>	-2.3820	-0.7573	-3.9689	-2.0988
<i>Phillips-Perron I (1)</i>	-18.288*	-14.159**	-23.3***	-17.434***

Note. t-statistic ***, ** and * means significance at 1%, 5% and 10%, created by using Eviews 10

Fluctuations of crude oil prices and an overall upward trend are noticed. There was a sharp decrease in the first period of the pandemic in March and continued until the end of April. After that, the oil prices faced an increasing trend in the summer period. One reason for that is the retaining of countries back to normal life and economic activities after the government remove the curfew because of the restrictions applied by the government to reduce coronavirus infections. Crude oil prices increased to reach their average level during the pre-pandemic period as both supply and demand for energy fell and inventories were overloaded. The second reason is that, while oil-buying nations like Turkey profited from the drop in oil prices by importing cheap crude oil and topping off their oil inventories, the pandemic hurt oil producers by limiting the supply and also negatively impacted importers by lowering demand. The cases began in march with a flat increase, but this increase became huge and doubled to reach its peak in Nov 2020, in this time the Turkish government applied the curfew on the country to reduce the cases by this social distancing restrictions and lockdown regulations, also the appeal of the vaccination reduced the cases of infected people to around 11553 cases at the end of April 2021, but the average cases

²¹ Explantation for the table 17 in Appendix C

are still higher than the starting period of the pandemic. However, the situation differs after the government imposed the COVID-19 vaccination on every citizen in the country, unless the cases will not be reduced. There is a peak between October and November 2020 which shows the high number of infected people in Turkey in this period before the government arrange for some regulations and restriction to limit the number of people infected with coronavirus pandemic. Actually, Turkey is one of the highest rates of infected cases of coronavirus in the world.

2. Autoregressive Distributed Lag Model Estimation Procedure

The procedure consists of three steps, in the first step the optimal lag of the autoregressive distributed lag model (ARDL) should be chosen. The second step is to check for the cointegration relationship. After estimating the type of the relationship as short run and long, the short run vector autoregressive model (VAR) or the long run error correction model (ECM) could be estimated and analyzed econometrically.

1. Lag Selection of ARDL Model

In the first step the ARDL Model order is determined. As in Table 18, the model with the minimum value of both information criteria AIC and SIC is chosen. The following table gives the values of the two criteria for the different three models at $p = 2, 4$, and 6 lags. ARDL models are devoid of residual correlation, according to Pesaran (2001). As a result, there are no endogeneity difficulties with proper lag selection. As can be seen in Table 18 all three models are of lag 4.

Table 18*Lag Structure Criteria Selection of ARDL Model*

Number of lags	Model 1: Brent Oil Price		Model 2: VIX Index		Model 3: BIST-100 Index	
	AIC	Schwartz	AIC	Schwartz	AIC	Schwartz
P = 6	3.584484	3.950811	5.232386	5.598713	8.756333	9.122660
P = 4	3.538118*	3.79842	5.193960*	5.454262	8.714908*	8.975210
P = 2	3.566290	3.721665	5.248638	5.430850	8.735304	9.047666

Note. AIC information criteria serves as the foundation for choosing the best lag; all ARDL models are consist of 4 lags, created using Eviews 10

To calculate the relationship between oil prices, COVID-19, VIX, and BIST-100 Indexes, we use the ARDL model developed by Pesaran (2001). When determining the long-term equilibrium, it uses an Error Correction Modulation and a linear transformation to account for short-term variations. These are the three ARDL Models:

i. Brent Oil Price ARDL Model:

$$\Delta Brent_t = c + p_1 Brent_{t-1} + p_2 covid19_{t-1} + p_3 Bist100_{t-1} + p_4 vix_{t-1} + \sum_{i=1}^4 \lambda_i \Delta Brent_{t-i} + \sum_{i=1}^4 \lambda_i \Delta covid19_{t-i} + \sum_{i=1}^4 \lambda_i \Delta Bist100_{t-i} + \sum_{i=1}^4 \lambda_i \Delta vix_{t-i} + \theta ECT_{t-i} + \varepsilon_t \quad (5.34)$$

ii. VIX Index ARDL Model:

$$\Delta VIX_t = c + p_1 Brent_{t-1} + p_2 covid19_{t-1} + p_3 Bist100_{t-1} + p_4 vix_{t-1} + \sum_{i=1}^4 \lambda_i \Delta Brent_{t-i} + \sum_{i=1}^4 \lambda_i \Delta covid19_{t-i} + \sum_{i=1}^4 \lambda_i \Delta Bist100_{t-i} + \sum_{i=1}^4 \lambda_i \Delta vix_{t-i} + \theta ECT_{t-i} + \varepsilon_t \quad (5.35)$$

iii. BIST-100 Index ARDL Model:

$$\Delta BIST100_t = c + p_1 Brent_{t-1} + p_2 covid19_{t-1} + p_3 Bist100_{t-1} + p_4 vix_{t-1} + \sum_{i=1}^4 \lambda_i \Delta Brent_{t-i} + \sum_{i=1}^4 \lambda_i \Delta covid19_{t-i} + \sum_{i=1}^4 \lambda_i \Delta Bist100_{t-i} + \sum_{i=1}^4 \lambda_i \Delta vix_{t-i} + \theta ECT_{t-i} + \varepsilon_t \quad (5.36)$$

Where: i is the maximum number of lags (in our case $p = 4$)

The Wald and Bound tests' F-statistic is used to determine whether a long-run association exists. A series of post-estimation tests are carried out to check for any residual serial correlation (Breusch-Godfrey LM test). Additionally, the CUSUM test is employed to assess the models' stability.

2. Testing for Cointegration Relationship

The Wald test assumes that the null hypothesis is $p_1 = p_2 = p_3 = p_4 = 0$ to check for the presence of a long-run connection. The thesis also used bound tests, which presupposed a lower bound for the I (0) series and an upper limit for the I (1) series, with critical values derived from Narayan (2005). The Wald test is the first test in Table 19 to show a long-term connection. The results showed a cointegration for model 1: Brent and model 2: VIX index with COVID-19 and other variables with 0.0037, 0.0003 probabilities at 5% significant level, respectively. However, no long run relationship appeared for BIST-100 index with a probability of 0.1347 at 5% significant level.

Moreover, long run form and bound test is used to reach for cointegration between the targeted parameters. The bound test presupposes that the F-statistic indicates a cointegration relationship if the values are higher than the lower bound's critical value. In the first two models with Brent and VIX as the dependent variables, a long-term link is found between oil prices, coronavirus counts, stock price volatility, and the Borsa Istanbul stock index. However, there is no cointegration when BIST-100 Index is the dependent variable in the third model, and these results are consistent with Wald test results. The bound tests show that the cointegration relationship is only demonstrated at a 10% significance level.

Table 19*Robustness Analysis for Long-Run relationship*

Wald test				
Model	F-statistic	Probability		Conclusion
Brent	$F_{\text{BRENT}}=3.981$	0.0037		Cointegration
VIX Index	$F_{\text{VIX}}= 5.419$	0.0003		Cointegration
BIST100 Index	$F_{\text{BIST100}}=1.772$	0.1347		No cointegration
Bound test				
Model	F-statistic	Critical values		Conclusion
		Lower bound	Upper bound	
		I (0)	I (1)	
Brent	$F_{\text{BRENT}}=3.123$	2.72	3.77	Cointegration at 10%
VIX Index	$F_{\text{VIX}}= 3.467$	2.72	3.77	Cointegration at 10%
BIST100 Index	$F_{\text{BIST100}}=0.744$	2.72	3.77	No cointegration

Note. (i) Probability at 5% significance level, (ii) Brent and VIX cointegration at 10% significant level.

3. Autoregressive Distributed Lag Model (ARDL) Estimation

The three ARDL models are estimated in the third stage (Table 20). At the beginning of the pandemic 11 March/2020 there was a huge decrease in crude oil price that it fell down to \$34, 5 and decreased 20% more as the number of infected cases increased until the middle of April to reach a minimum of \$14.19. After these two periods the price took an upward trend during the summer season when the global and Turkish governments reduced the restrictions and eliminated the lockdown. For that reason, an upward trend in crude oil prices is observed. Moreover, Turkey as an oil importing country has benefited from the reduction in oil prices. In this way, the inventory of crude oil could increase, preparing for more investment and economic activities in summer periods, before the Turkish government was exposed the second partial lockdown at the end of October. Overall, the downward trend can be seen at time of lockdown and an upward trend can be seen in time with no curfew for Turkey and the entire world. One possible theory is that as economic activity improves, demand for crude oil rises, causing oil prices to rise, which is about \$62.4 in April 2021. This can explain the significant relationship between oil prices and the daily infected cases in the long run.

Overall, there is a negative long-run correlation between Brent oil prices, coronavirus daily infected cases, volatility of stock market index and BIST-100 index was observed in Model 1, which can be estimated by an ECM Model for a level equilibrium relationship. In Model 1, the long run relationship can be approved by looking at the lag of the error correction term (ECT_1) probability 0.0006 at 5% significant level with a negative sign for its coefficient. All F statistics, however, were lower than 1.96 and were jointly negligible for the short run lagged variables' combined significance. ECM Model for Brent is:

$$\Delta \text{Brent}_t = -0.066100ECT_{1t-1} + \varepsilon_t \quad (5.37)$$

Considering that ECT_1 is the adjusted speed for long-term equilibrium, the variances in Brent oil prices require 6.61% speed in order to reach long-term equilibrium.

Moreover, from the coefficient of the lagged ECT_2 of the second model of VIX index with probability of 0.0007, indicates a positive granger causality long run relationship among VIX, COVID-19, Brent, and BIST-100. For short run coefficients in Model 2, Wald test results illustrates that, the F-statistics = 2.54 and 14.03 > 1.96 for BIST-100 and

VIX indexes, respectively, which indicated that there is a negative ceteris paribus impact (other things being equal) from BIST-100 to VIX in the short run. The ECM Model for VIX Index is:

$$\begin{aligned}\Delta VIX_t = & 0.00617\Delta BIST100_{t-1} + 0.0142\Delta BIST100_{t-2} + 0.0084\Delta BIST100_{t-3} - \\ & 0.0264\Delta BIST100_{t-4} - 0.268\Delta vix_{t-1} + 0.2118\Delta vix_{t-2} + 0.2204\Delta vix_{t-3} - 0.04251\Delta vix_{t-4} - \\ & 0.09688ECT_{2t-1} + \varepsilon_t\end{aligned}\quad (5.38)$$

Where:

- The adjusted speed for long-term equilibrium is known as the ECT_2 , which means that the VIX Index's deviations must move at a 9.96% speed in that direction.
- The model's short run dynamic coefficients are those of the lagged variables given by Δ .

Table 20 reports that when BIST-100 index is the dependent variable in Model 3, there is a negative short run correlation between BIST-100 index and COVID-19. Besides, the short run ARDL Model concludes a direct significant correlation between BIST-100 index and Brent oil prices. To this extent, this relationship can be approved by looking at the joint significance F statistic of the short run coefficients. From the table, there are two short run ceteris paribus effects²², one from Brent oil prices to BIST-100 index and the other from COVID-19 number of infected cases. This result was tested by Wald test for joint significance and shows F statistic values of 2.75, $2.55 > 1.96$ for Brent and COVID-19, respectively. However, the statistic results show F value = 0.11, $0.97 < 1.96$ for BIST-100 and VIX index, which are jointly insignificant. The negative and insignificant ECT_3 with a probability of $0.302 > 5\%$ significant level indicates a no cointegration of the estimated model in the long run, and the coefficients of the lagged COVID-19 and Brent-op are the short run dynamic coefficients. The short-run ARDL Model for BIST-100 Index is:

$$\begin{aligned}\Delta BIST100_t = & 0.987135\Delta BRENT_{t-1} - 0.247846\Delta BRENT_{t-2} + 2.308225\Delta BRENT_{t-3} + \\ & 0.777118\Delta BRENT_{t-4} - 0.0010035\Delta COVID19_{t-1} - 0.00098859\Delta COVID19_{t-2} + \\ & 0.00039\Delta COVID19_{t-3} - 0.00044226\Delta COVID19_{t-4} + \varepsilon_t\end{aligned}\quad (5.39)$$

²² Ceteris Paribus Effect: means with other conditions remaining the same; other things being equal.

Table 20

Estimation of the COVID-19's ARDL Model

	Model 1:		Model 2:		Model 3:	
	Brent Oil Price		VIX Index		BIST-100 Index	
Long-Run Equation						
	coefficient	Prob.	coefficient	Prob.	coefficient	Prob.
VIX (-1)	-0.026197	0.0085	-0.056405	0.0135	0.238965	0.0713
BRENT (-1)	-0.070191	0.0004	-0.074820	0.0969	0.130454	0.6178
BIST100 (-1)	0.003314	0.0003	0.004204	0.0443	-0.009757	0.4207
COVID19 (-1)	-4.56E-06	0.6451	-3.09E-05	0.1730	0.000141	0.2855
Short-Run Equation						
	ECM Model (long-run)		ECM Model (long-run)		ARDL Model (short-run)	
DBRENT (-1)	-	-	-0.250093	0.0612	0.987135	0.2124*
DBRENT (-2)	-	-	-0.192299	0.1543	-0.247846	0.7570*
DBRENT (-3)	-	-	-0.053056	0.6913	2.308226	0.0039*
DBRENT (-4)	-0.012481	0.8339	0.045202	0.7367	0.777118	0.3308*
DCOVID (-1)	-1.61E-05	0.6878	1.57E-05	0.8610	-0.001004	0.0617*
DCOVID (-2)	2.36E-05	0.5647	-1.95E-05	0.8328	-0.000989	0.0731*
DCOVID (-3)	5.49E-06	0.8938	2.57E-05	0.7811	0.000391	0.4786*
DCOVID (-4)	3.72E-05	0.3609	6.41E-05	0.4845	-0.000442	0.4181*
DBIST100(-1)	-0.002064	0.6559	-0.006180	0.5543*	0.006470	0.9178
DBIST100(-2)	0.005376	0.2271	0.014230	0.1601*	0.027935	0.6447
DBIST100(-3)	-0.006369	0.1521	0.008418	0.4035*	-0.015097	0.8022
DBIST100(-4)	-0.004624	0.2795	-0.026419	0.0065*	0.020457	0.7242
DVIX (-1)	0.007025	0.7881	-0.269000	0.0000*	0.050234	0.8859
DVIX (-2)	0.040404	0.1372	0.211854	0.0008*	0.611660	0.0943
DVIX (-3)	0.041058	0.1275	0.220447	0.0004*	-0.074141	0.8348
DVIX (-4)	0.002223	0.9306	-0.042512	0.4670*	0.002856	0.9933
ECT (-1)	-0.066100	0.0006**	-0.096882	0.0007**	-0.014948	0.3020
Test						
Serial correlation	NO		NO		NO	
Stability	YES		YES		YES	

Note. (i) **denotes the long-term relationship's significance of the error correction term at 5%; (ii) * Wald test for the variable lags' combined significance in the short-run relationship; (iii) For serial correlation, the Breusch-Godfrey LM test is utilized; (iv) CUSUM tests are performed to assess stability; (v) The residuals will be extracted using long-run equations to build the ECT.

5.4.4 Econometrical results of COVID-19 effect on stock and energy indicators

COVID-19 daily infected cases impact on crude oil market, Borsa Istanbul Index, and stock market volatility index from March 11, 2020 to April 12, 2021 were investigated by estimating an ARDL model. Moreover, Wald and Bound cointegration tests were applied to test the long run correlation.

The methodology estimated that an increase in COVID-19 active cases has a negative reaction on crude oil market in the long run. However, oil price changes started to respond to COVID-19 in the beginning of March 09, 2020, which is 49 days after the first case of infection was recorded by World Health Organization (WHO, 2020). However, the average of Brent crude oil price in April/2021 is about \$62.3, which is nearly the same as the price of the previous year of 2019 before the outbreak of coronavirus pandemic crisis. This provides an explanation for the discouraging findings in earlier studies, such as Albulescu (2020a), who examined cases during the first phase of the epidemic. However, a lengthy period of daily data from the start of the pandemic through April 2021, with lockdowns during some of those times and increases in economic activity during others, causes crude oil prices to fluctuate over the long term.

Additionally, the uncertainty of the stock market appears to have been more affected by the new COVID-19 situation than crude oil prices. This study explains the direct trend that as the infected cases increased, people and investors become more sensitive to invest and join in production projects because of the uncertainty in the Turkish economic markets, which increase the volatility index in the long run. Surprisingly, the Turkish stock market's declining VIX index in the long run has a strong and important relationship with other sectors. This maybe because the foreign market's growing uncertainty draws foreign investors to the Turkish market as it is considered as more stable economy.

Lastly, the study illustrates that as the number of infected cases increase, a reduction in Borsa Istanbul Index (BIST-100) estimated in the short run. Consequently, BIST-100 index lost 11% of its value in 25-day period at the beginning of the pandemic (Investing, 2021). The markets mostly valued the effects of the epidemic in the next period, and so the stock index began to rebound. That can be approved by the significance of the second lag of COVID-19 indicator in the short run ARDL model. However, since the onset of the epidemic, the stock index has swung at high levels. This way the temporary effect of COVID-19 on BIST-100 Index of the Turkish stock market can be explained.

In chapter 5, there was an econometrical and analytical analysis for the two sections of the thesis. The long- and short-term effects of monthly data shocks related to Brent crude oil on CPI, TIP, TPP, NG-IP, and EX (TRY/USD) were examined in the first section. The second part examined the effects of daily observations of COVID-19 infections on price of Brent oil, VIX index, and BIST-100 index. The next chapter 6, will be the final conclusion and analysis of the thesis targeted series. Furthermore, there will be suggestions for policy makers and investors for more better economic future. Besides that, there will be explanation for the thesis limitations and suggestions for new economic researches.

CHAPTER 6

DISCUSSION

The study findings should be analyzed both economically and econometrically. In terms of economics, a change in oil prices has an impact on economic growth over such a lengthy period of time in Turkey. Economic and political viewpoints about manufacturing inputs that has such a long-term impact on economic growth are crucial for Turkey which lack energy resources. Erdogan, Gedikli, and Kırca (2019) indicated that an unavoidable impact of oil price on economic growth will influence both oil production and non-oil industries through imports.

In model 1, the thesis revealed a positive relationship from Brent oil price to CPI in the long run by an ECM model. This result is consistent with previous literatures of Al Rasasi and Yilmaz (2016), Bhattacharjee (2013), Gökmenoğlu, et al. (2015), Çelik and Akgül (2011), and Aktaş, et al. (2010) who studied the macroeconomic factor of CPI. However, the results estimated a positive relationship between the exchange rate and CPI in the short run that is investigated by Wald test. The Turkish currency depreciation against US dollar significantly increases the price inflation in Turkey.

This thesis proposes that Turkey policy makers should expand the energy subsidy program to manufacturers in order to assist them in combating price inflation. Nonetheless, reducing the energy subsidy amid a decrease in oil prices is not suggested. To boost economic welfare and price competitiveness, it is recommended to take advantage of lower energy prices. Higher (lower) price inflation is projected as a result of currency depreciation (appreciation). Furthermore, the exchange rate has a greater impact on price inflation than the price of oil. As a result, monetary policy aimed at strengthening the currency is beneficial to price stability. A strong currency boosts export competitiveness by lowering the cost of imported inputs. Economies of scale will result in the ability of creating more units of product on a greater scale with lower input costs.

In model 2, the study's findings demonstrate that oil price variations affect Turkey's total industrial production index, as a proxy for GDP since monthly data for Turkish GDP is unavailable and this is one of the limitations of the research. Findings are similar to those

of Serletis and Shahmoradi (2005) and Ewing and Thompson (2007). Furthermore, the thesis illustrates that the total petroleum and other liquids production has a negative effect on total industrial production index in the short run. Turkey lacks sufficient fossil fuel resources, and its economy is largely reliant on importing crude oil, for which there is currently no substitutes. The industrial sector's reliance on imported crude oil puts the country sensitive to fluctuations in oil prices.

Given the link between oil prices and industrial output, policy makers claimed to hedge against oil price volatility, which is a critical component for Turkey to maintain a sustainable and steady industrial production, at least in the short and medium term. Dynamic consumption might be another alternative for a developing country that relies on imported oil and is subject to price fluctuations.

Future research should focus on the primary benefits and drawbacks of these tactics in the context of Turkey, as well as other available solutions. Prospective research should be used to develop long-term solutions, such as identifying oil alternatives, to reduce the industrial sector's reliance on fossil fuels. Another impetus for future study maybe to look at the link between these variables while accounting for any structural breaks and/or non-linear relationships. Another suggestion for future researches is to put an eye on greenhouse projects and make more researches for circular economy, besides socioeconomic development studies. One of the achievements of the Turkish Government is the TOGG vehicles in Oct 2022 (Ozbek, 2022), which is the first electric car domestically produced in Turkey. This achievement helps in reducing the consumption of oil and fossil fuels. Moreover, another aim is to make a defense against the depreciation in Turkish lira and the huge inflation in Turkey.

In the Turkish gas market, crude oil prices have a considerable long-term beneficial influence on natural gas import prices as investigated in model 3. Moreover, the exchange rate shows a positive impact on natural gas prices in the short run. These results are consistent with Jia, Geng, and Fan (2014) and Panagiotidis and Rutledge (2007). Using the Johansen approach, this study shows that Turkey's natural gas prices are cointegrated with oil prices, using European natural gas import prices as a proxy since data for Turkey's natural gas import prices are unavailable, which is the second limitation of the study.

In the long run, gas and oil prices move together, taking in consideration oil price shocks can provide valuable market information to policymakers and energy companies. Moreover, to help importing countries and related businesses in adjusting their trade and production strategies. It also allows them to measure the risks and costs of natural gas import to reduce risk of investment and ensure the security of natural gas supply.

In model 4, a positive long run relationship between Brent oil price and total petroleum and other liquids production was investigated. After comprehensive research, only a few studies in the literature were found which studied the total petroleum and other liquids production, which is the third limitation of the study. That is probably because Turkey is highly dependent on oil imports as an oil importing country.

However, this thesis will contribute to help policy makers in Turkey to work to increase the percentage of renewable energy sources in the national energy mix and to add nuclear power to the mix, in order to reduce its reliance on imported energy, maximize the use of domestic resources, and battle climate change. Moreover, Turkey aspires to be a regional hub for energy commerce. Turkey has undertaken and completed numerous major natural gas and oil pipeline projects in the area in order to achieve this goal.

A positive long run correlation between Brent oil price shocks and the exchange rate (TRY/USD) is detected in model 5. This result is consistent with previous literature of Al Rasasi and Yilmaz, (2016), Akçelik and Ogünç (2016), Eryigit (2012), Köse and Emre (2021), and Doğan, et al. (2012). This is significant as the short-run deviations are around two periods away from reaching the long-run equilibrium value. Turkish currency depreciation versus the dollar has recently intensified, which is associated with rising crude oil and commodity prices.

As reported in Bloomberg (2021), the Turkish economy's enormous current account deficit and massive quantities of private foreign-currency denominated debt between Sep – Dec/2021. However, at the end of Dec/2021, the government supports the Turkish lira, including the launch of a new program to protect deposits against currency volatility. The government would compensate depositors for losses, ensuring that the lira's depreciation versus hard currencies does not surpass interest rates provided by banks. Steps are summarized as follows:

1. Authorities will issue non-deliverable futures to aid exporters in reducing foreign-exchange risks posed by rising volatility.
2. Turkey has neither the will nor the need to back away from the free-market economy or the international monetary system.
3. Investments in government-issued lira notes will be subject to a 0% withholding tax, down from 10%.
4. The government would match 30% of all payments to the optional pension scheme made by private-sector workers, up from the existing level of 25% (Bloomberg, 2021).

Furthermore, the macroeconomic performance indicators in economic growth are weak due to its energy import dependency and volatility in oil prices. Another finding is that lower oil prices may have a favorable impact on economic growth. With an epidemic like COVID-19, dramatic drops in oil prices may have a favorable impact on economic development in energy-importing nations like Turkey, because oil price shocks are lasting, even after the epidemic is over. As a result, governments must establish energy policies that take into consideration the long-term impact of oil prices on economic growth. Turkey must look to alternate energy sources for long-term macroeconomic performance in order to control the impact of oil price shocks on economic growth.

With an emphasis on the epidemic phase of the crisis in 2020 and 2021, we investigated the effect of COVID-19 official statements on the financial volatility index (VIX), Borsa Istanbul Index (BIST-100), and Brent oil price (BRENT). The study examines the daily infected cases impact on stock and energy indexes, for that reason the study chose only these variables as they are available in daily basis, as most variables are most afforded in monthly or quarterly basis. In order to achieve this, we have used the volatility of the BIST-100 and VIX indices as benchmarks for Turkey's financial markets.

The outcomes of our empirical investigation underline the fact that: (i) the new infection cases reported at Turkey level amplify the financial volatility in the long run, in contrast, Sarı and Kartal (2020) found the same results in the short run, (ii) Long-term effects on the crude oil market are adversely affected by an increase in COVID-19 infections. In this way the negative results for previous literatures, such as Albulescu

(2020a), who studied the cases at the first period of the pandemic, can be explained. On the other hand, Aydın and Ari (2020), McKibbin and Fernando (2020), Mzoughi, et al (2020), Sercan, et al. (2020), and others investigated a negative short run relationship between oil prices and COVID-19 cases, (iii) the new COVID-19 condition seems to have had a greater effect on stock market uncertainty compared to Brent oil price shocks, (iv) The Turkish stock market's declining VIX index in the long run has a strong and important relationship with other sectors. This maybe because the foreign market's growing uncertainty draws foreign investors to the Turkish market as it is considered as more stable economy and high level of tourism in summer periods, (v) the increase in the number of infected cases and the temporary reduction in BIST-100, can be explained by the short run ARDL model, matching results with Özkan (2020).

To sum up, our thorough investigation showed that the COVID-19 problem' longevity and the uncertainty it causes increase the volatility of Turkey's financial markets. Investors' sentiments are likely to shift as more information about the number of infections, vaccinations, and treatment for the virus become more reachable in Turkey. As a result, this study tries to cover a large period of time to get data on the issue that is needed including fresh information to give strong policy implications for policymakers as well as information for investors and companies in their decision-making process. The pandemic caused Turkey's government to implement both urgent short-term loan possibilities and long-term alternatives for direct income support, tax deferrals, and interest rate modifications in response to the crisis.

The thesis suggests new topics for future researches as looking Forward for the positive effect of COVID -19 specially in circular economy, and study the period of 2022 and how the pandemic still indirectly affect inflation and energy market. The crisis of COVID-19 pandemic is still hitting Asia and Europe economies more than other countries (Mckinsey and Company, 2022), which make it argent to shed a light on the economic risk responses of the pandemic for these countries. As can be seen that the effect of this pandemic is still continued but with less announcements, and this is other limitation of the study is that this pandemic is endless until this period.

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Appendix

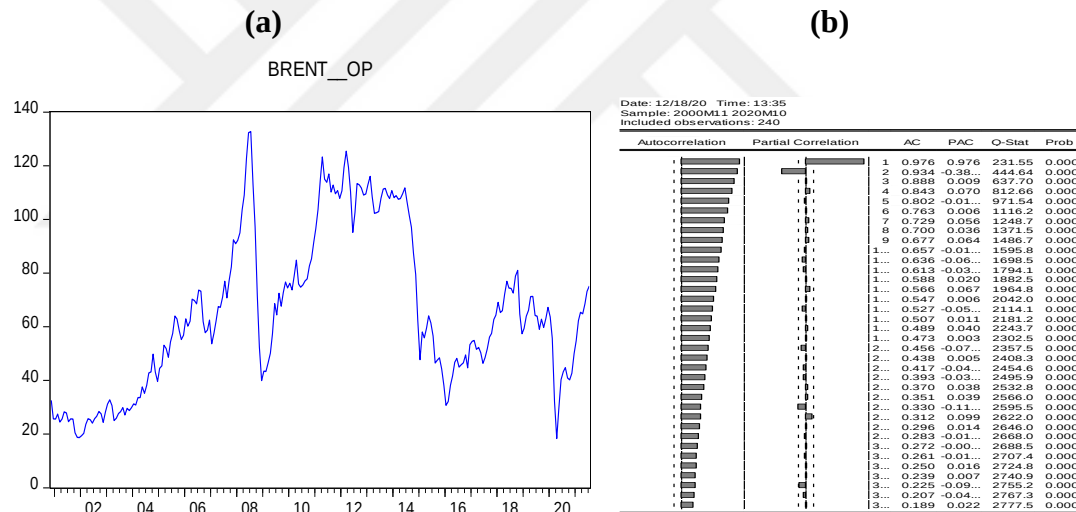
Appendix A: Study of the Stationarity of Economic Indicators

Section 1: Study of Brent oil price series stationarity (Nov. 2000- July 2021)

1. Graph analysis of monthly Brent oil price

Figure 19

Chart and Correlogram Analysis (Brent oil price)



Note. Created using the Eviews 10

- 1) Figure 19a: Fluctuations of the prices and an overall upward trend have been noticed. It means that the series is non-stationary.
- 2) Figure 19b: The auto correlation function: the terms decrease slowly to 0: which implies that there is trend effect, so the price of Brent oil will not be stationary. The partial auto correlation function: there is a single significant peak, matched to the delay n° 1 AR (1).

2. Stationarity test of the Brent_OP series:

Table 21

Selection of the delay number of Brent_OP

Delay number (p)	Model 1		Model 2		Model 3	
	AIC	Schwarz	AIC	Schwarz	AIC	Schwarz
P=0	6.282001	6.296547	6.280577	6.309669	6.287407	6.331045
P=1	6.088998	6.118177	6.072116	6.115884	6.080516	6.138874
P=2	6.097599	6.141499	6.083313	6.141846	6.091752	6.164918
P=3	6.094036	6.152745	6.084309	6.157695	6.092653	6.180717
P=4	6.104529	6.178137	6.093560	6.181890	6.101778	6.204829

Note. The number that minimizes the Akaike and Schwarz criteria is p= 1

3. Augmented Dickey-Fuller test:

Table 22

ADF Test for Brent Oil Price

Model [1]		Model [2]		Model [3]	
calculated $t_{\hat{\phi}}$	tabulated $t_{\hat{\phi}}$	calculated $t_{\hat{\phi}}$	tabulated $t_{\hat{\phi}}$	calculated $t_{\hat{\phi}}$	tabulated $t_{\hat{\phi}}$
	$\alpha=1\%$:		$\alpha=1\%$:		$\alpha=1\%$:
	-2.574714		-3.457747		-3.997083
-0.905846		-2.614317		-2.455717	
	$\alpha=5\%$:		$\alpha=5\%$:		$\alpha=5\%$:
	-1.942164		-2.873492		-3.428819
	$\alpha=10\%$:		$\alpha=10\%$:		$\alpha=10\%$:
	-1.615810		-2.573215		-3.137851

Note. Created by using Eviews 10

Since the calculated values t_φ are higher than all the tabulated values, H_0 of existence of a unit root is accepted hence oil price is non-stationary. The basic models are as follows:

$$\text{Models [1]: } \Delta x_t = \rho x_{t-1} + \sum_{i=1}^p \lambda_i \Delta x_{t-1} + \varepsilon_t \quad (1.1)$$

$$\text{Models [2]: } \Delta x_t = \rho x_{t-1} + \sum_{i=1}^p \lambda_i \Delta x_{t-1} + c + \varepsilon_t \quad (1.2)$$

$$\text{Models [3]: } \Delta x_t = \rho x_{t-1} + \sum_{i=1}^p \lambda_i \Delta x_{t-1} + c + bt + \varepsilon_t \quad (1.3)$$

Where $\rho = (1 - \phi_1)$ and $c = (1 - \Phi_1)\mu$, $b = (1 - \Phi_1)\beta$

a. ADF test in model [3]:

$$\Delta \text{Brent_OP}_t = \rho \text{brent_op}_{t-1} + c + bt + \lambda_1 \Delta \text{brent_op}_{t-1} + \varepsilon_t \quad (1.4)$$

Testing the nullity of the coefficient of the trend. Test of the constant nullity of b by t -statistic test of:

$H_0 : b=0$ the trend is not significant

$H_1 : b \neq 0$ the trend is significant

H_0 is rejected if $T_{\text{Cal}} > T_{\text{Tab}}$

$T_{\text{Cal}} = -0.027174 < T_{\text{Tab}} = 1, 96$, significance threshold of 5%. H_0 is not rejected: The trend in this case is insignificant. Then model (3) is not the right model.

Test the existence of a unit root

$H_0 : \Phi = 0$ Existence of a unit root

$H_1 : \Phi < 0$ not existence of a unit root

H_0 is rejected if $\text{ADF}_{\text{Cal}} > \text{ADF}_{\text{Tab}}$.

$\text{ADF}_{\text{Cal}} = 2.614317 < \text{ADF}_{\text{Tab}} = 2.873492$ at threshold of 5% therefore H_0 is not rejected suggesting the existence of a unit root ($0, 0363 < 0, 05$)

Test the nullity of the constant

$H_0 : c=0$ absence of the constant

$H_1 : c \neq 0$ existence of the constant

H_0 is rejected if $T_{\text{Cal}} > T_{\text{Tab}}$

$T_{\text{Cal}} = 2.453108 > T_{\text{Tab}} = 1, 96$ at threshold of 5% so (with Prob. $0, 0006 < 0, 05$) therefore H_0 is rejected suggesting the presence of the constant. Consequently, the process generating

the series is not stationary, it is of DS type. Unit root is not rejected so a Fisher test of joint hypothesis is constructed: $\rho=0$ and $b=0$

$$H_0:(c, b, \rho) = (c, 0, 0)$$

$F_{3, cal} = 19.71310 < F_3$ at 5% do not reject null hypothesis of trend ($b=0$) conditionally on the presence of a unit root shown in the table. So, the model [3] is not the right one, proceed to model [2].

b. ADF test in the model [2]:

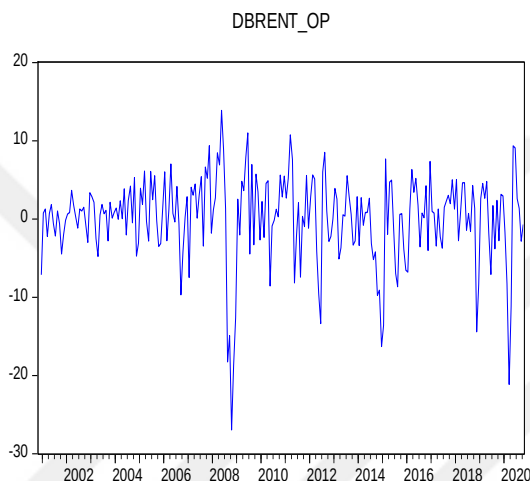
$$\Delta \text{Brent_op}_t = \rho \text{Brent_op}_{t-1} + c + \lambda_1 \Delta \text{Brent_op}_{t-1} + \varepsilon_t \quad (1.5)$$

Test the nullity of the constant: Unit root is not rejected then a Fisher test of joint hypothesis is constructed: $\rho=0$ and $c=0$: $(c, \rho) = (0, 0)$. $F_{2, cal} = 29.69556 > F_2$ 18.5128 at 5%; thus reject the null of the constant ($c=0$) conditionally on the presence of a unit root shown in the table. So, the model [2] is the right one.

4. Stationarities of the Brent_OP series:

The correct method of stationarities of the BRENT_OP series is to use the first differences:

$$\Delta \text{Brent_OP} = \text{Brent_OP} - \text{Brent_OP}(-1)$$

Figure 20*Chart and Correlogram analysis (Δ Brent_OP series)***(a)****(b)**

Date: 12/18/20 Time: 16:43
 Sample: 2000M11 2020M10
 Included observations: 239

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1	0.421	0.421	42.904	0.000	
2	0.143	-0.04...	47.869	0.000	
3	-0.06...	-0.12...	48.772	0.000	
4	-0.09...	-0.01...	50.935	0.000	
5	-0.09...	-0.04...	53.355	0.000	
6	-0.13...	-0.10...	57.779	0.000	
7	-0.09...	-0.00...	59.828	0.000	
8	-0.09...	-0.06...	62.000	0.000	
9	-0.05...	-0.01...	62.717	0.000	
1...	0.029	0.059	62.927	0.000	
1...	0.044	-0.01...	63.412	0.000	
1...	0.008	-0.05...	63.429	0.000	
1...	-0.06...	-0.07...	64.473	0.000	
1...	-0.07...	-0.03...	65.995	0.000	
1...	0.027	0.093	66.182	0.000	
1...	0.021	-0.03...	66.297	0.000	
1...	-0.01...	-0.05...	66.330	0.000	
1...	-0.05...	-0.03...	67.085	0.000	
1...	0.006	0.055	67.094	0.000	
2...	0.025	-0.00...	67.253	0.000	
2...	0.065	0.044	68.386	0.000	
2...	0.066	0.013	69.546	0.000	
2...	0.002	-0.04...	69.548	0.000	
2...	-0.05...	-0.04...	70.485	0.000	
2...	0.041	0.129	70.943	0.000	
2...	-0.05...	-0.15...	71.807	0.000	
2...	-0.05...	-0.00...	72.570	0.000	
2...	-0.08...	-0.01...	74.590	0.000	
2...	-0.06...	-0.02...	75.775	0.000	
3...	-0.01...	0.009	75.813	0.000	
3...	-0.00...	-0.02...	75.825	0.000	
3...	0.003	-0.04...	75.828	0.000	
3...	0.088	0.147	77.978	0.000	
3...	0.060	-0.03...	78.996	0.000	
3...	0.038	-0.02...	79.406	0.000	
3...	-0.03...	-0.05...	79.773	0.000	

Note. Created using Eviews 10

Figure 20a: The series seems stationary because the observations vary around their mean (the series varies around its mean). Figure 20b, from the auto correlation function, it appears that the trend effect is eliminated. So, in general the series is stationary. This conclusion is concluded by the augmented Dickey-Fuller test.

Table 23*ADF Test for Δ Brent_OP*

Model [1]		Model [2]		Model [3]	
calculated	tabulated $t_{\hat{\phi}}$	calculated	tabulated $t_{\hat{\phi}}$	calculated	tabulated $t_{\tilde{\phi}}$
$t_{\hat{\phi}}$		$t_{\tilde{\phi}}$		$t_{\tilde{\phi}}$	
	$\alpha=1\%:$		$\alpha=1\%:$		$\alpha=1\%:$
-9.8661	-2.57471	-9.84641	-3.45774	-9.87834	-3.99708
	$\alpha=5\%:$		$\alpha=5\%:$		$\alpha=5\%:$
	-1.94216		-2.87349		-3.42881
	$\alpha=10\%:$		$\alpha=10\%:$		$\alpha=10\%:$
	-1.61581		-2.57321		-3.13785

Note. Created by using Eviews 10

The calculated values are all below the tabulated values for the three models $\Rightarrow$ the unit root does not exist, and then the series Δ Brent_OP is stationary. Since the hypothesis of existence of a unit root is rejected the series:

Brent_OP is non-stationary:

Brent_OP I (1)

Δ Brent_OP is stationary:

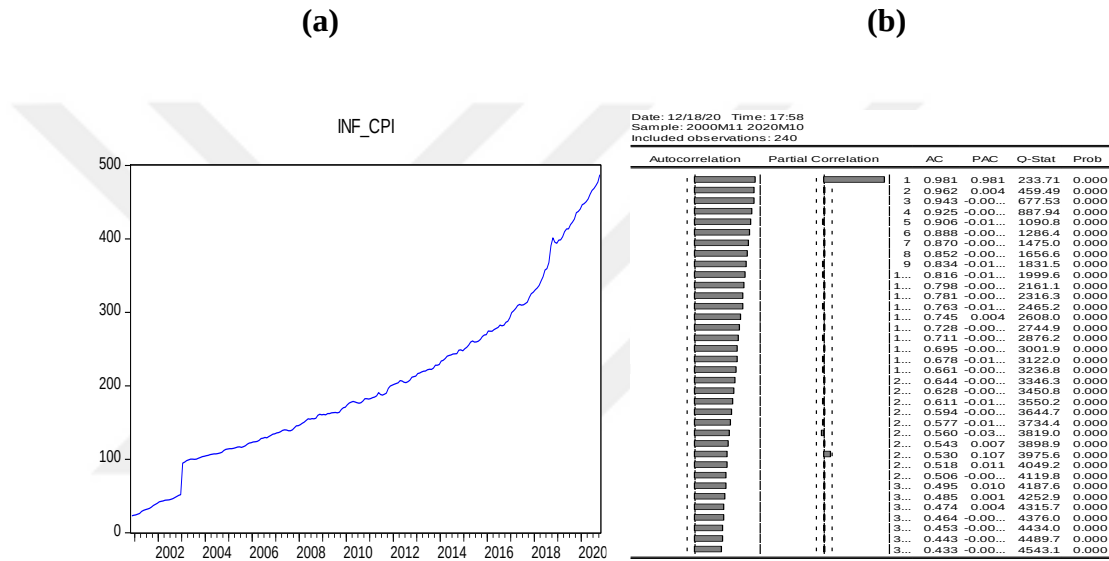
Δ Brent_OP I (0)

Section 2: Study of Inflation Rate (CPI) Stationarity

1. Graph Analysis:

Figure 21

Chart and Correlogram Analysis (CPI)



Note. Created using Eviews 10

- 1) Figure 21a: Fluctuations of CPI and an overall upward trend are noticed.
- 2) Figure 21b: Auto correlation function: terms decrease slowly to 0: which implies that there is trend effect, so CPI will not be stationary. Partial auto correlation function: there is a single significant peak, matched to the delay n° 1 AR (1).

2. Stationary Test of CPI Series:

Table 24

Selection of the delay number (CPI)

Delay number	Model 1		Model 2		Model 3	
	AIC	Schwarz	AIC	Schwarz	AIC	Schwarz
P=0	5.378400	5.392946	5.384042	5.413133	5.386693	5.430331
P=1	5.375687	5.404866	5.381819	5.425587	5.387147	5.445505
P=2	5.384981	5.428880	5.391006	5.449539	5.394968	5.468134
P=3	5.395211	5.453920	5.401538	5.474924	5.406506	5.494570
P=4	5.407909	5.481518	5.414357	5.502687	5.419067	5.522119

Note. The number that minimizes the Akaike and Schwarz criteria is p= 1

3. Augmented Dickey-Fuller test:

Table 25

ADF Test for CPI

Model [1]		Model [2]		Model [3]	
<i>calculated</i> $t_{\hat{\phi}}$	tabulated $t_{\hat{\phi}}$	<i>calculated</i> $t_{\hat{\phi}}$	tabulated $t_{\hat{\phi}}$	<i>calculated</i> $t_{\hat{\phi}}$	tabulated $t_{\hat{\phi}}$
9.20511	$\alpha=1\%:$ -2.57467	3.73818	$\alpha=1\%:$ -3.45763	2.08022	$\alpha=1\%:$ -3.99691
	$\alpha=5\%:$ -1.94215		$\alpha=5\%:$ -2.87344		$\alpha=5\%:$ -3.42873
	$\alpha=10\%:$ -1.61581		$\alpha=10\%:$ -2.57318		$\alpha=10\%:$ -3.13780

Note. Created by using Eviews 10

Since the calculated values t_{φ} are all higher than the tabulated values, H_0 of existence of a unit root is accepted; CPI is non stationary.

a. ADF test in model [3]:

$$\Delta \text{CPI}_t = \rho \text{CPI}_{t-1} + c + b t + \lambda_1 \Delta \text{CPI}_{t-1} + \varepsilon_t \quad (1.6)$$

Testing the nullity of the coefficient of the trend. Test of the constant nullity of b by a t-statistic test of:

$H_0 : b=0$ the trend is not significant

$H_1 : b \neq 0$ the trend is significant

H_0 is rejected if $T_{\text{Cal}} > T_{\text{Tab}}$

$T_{\text{Cal}} = -1.163153 < T_{\text{Tab}} = 1.96$, significance threshold of 5%. Therefore H_0 of the trend is insignificant is not rejected. Then model (3) is not the right model.

Test the existence of a unit root

$H_0 : \Phi = 0$ Existence of a unit root

$H_1 : \Phi < 0$ not existence of a unit root

H_0 is rejected if $\text{ADF}_{\text{Cal}} > \text{ADF}_{\text{Tab}}$

$\text{ADF}_{\text{Cal}} = 2.080223 < \text{ADF}_{\text{Tab}} = -3.428739$ at threshold of 5% therefore H_1 of absence of a unit root is rejected.

Test the nullity of the constant

$H_0 : c=0$ absence of the constant

$H_1 : c \neq 0$ existence of the constant

H_0 is rejected if $T_{\text{Cal}} > T_{\text{Tab}}$

$T_{\text{Cal}} = 0.775044 < T_{\text{Tab}} = 1.96$ at threshold of 5% therefore, H_0 of the absence of the constant is not rejected. Unit root is not rejected so a Fisher test of joint hypothesis is constructed:

$\rho=0$ and $b=0$

$H_0 : (c, b, \rho) = (c, 0, 0)$

$F_{3, \text{cal}} = 7.673884 < F_3 9.5521$ at 5%, the null hypothesis of trend ($b=0$) conditionally on the presence of a unit root shown in the table is not rejected. Model [3] is not the right one; proceed to model [2].

b. ADF test in the model [2]:

$$\Delta \text{CPI}_t = \rho \text{CPI}_{t-1} + c + \lambda_1 \Delta \text{CPI}_{t-1} + \varepsilon_t \quad (1.7)$$

H_0 : $c=0$ absence of the constant

H_1 : $c \neq 0$ existence of the constant

H_0 is rejected if $T_{\text{Cal}} > T_{\text{Tab}}$

$T_{\text{Cal}}=0.804427 < T_{\text{Tab}}=1,96$ at threshold of 5%, therefore H_0 of the absence of a constant is not rejected. Consequently, the process generating the series is non-stationary, it is of DS type.

Test the nullity of the constant: Unit root is not rejected then a Fisher test of joint hypothesis is constructed: $\rho=0$ and $c=0$ (c, ρ) = (0, 0). $F_2, \text{cal} = 13.97404 < F_2 18.5128$ at 5%; H_0 of the constant ($c=0$) conditionally on the presence of a unit root shown in the table is not rejected. Model [2] is not the right; proceed to model [1].

c. Augmented Dickey-Fuller test for the model [1]:

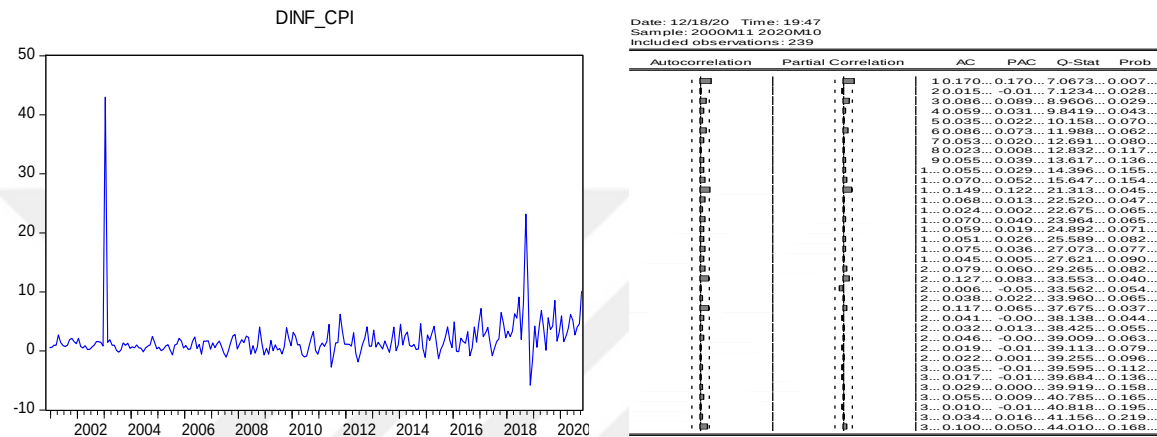
$$\Delta \text{CPI}_t = \rho \text{CPI}_{t-1} + \lambda_1 \Delta \text{CPI}_{t-1} + \varepsilon_t \quad (1.8)$$

(INF_CPI) is non-stationary of DS type without drift.

4. Stationarization of the series:

The correct method of Stationarization of the CPI series is to use the first differences:

$$\Delta \text{CPI} = \text{CPI} - \text{CPI}(-1)$$

Figure 22*Chart and Correlogram Analysis (ΔCPI)***(a)****(b)**

Note. Created using Eviews 10

Figure 22a: The series seems stationary because the observations vary around their mean (the series varies around its mean). Figure 22b, from the auto correlation function, it appears that the trend effect is eliminated. So, in general the series is stationary. This conclusion is confirmed by the augmented Dickey-Fuller test.

Table 26*ADF test on the series ΔCPI*

Model [1]		Model [2]		Model [3]	
calculated	tabulated	calculated	tabulated	calculated	Tabulated
$t_{\hat{\phi}}$	$t_{\hat{\phi}}$	$t_{\hat{\phi}}$	$t_{\hat{\phi}}$	$t_{\hat{\phi}}$	$t_{\hat{\phi}}$
	$\alpha=1\%$:		$\alpha=1\%$:		$\alpha=1\%$:
-5.34499	-2.57479	-12.7383	-3.45774	-13.2231	-3.99708
	$\alpha=5\%$:		$\alpha=5\%$:		$\alpha=5\%$:
	-1.94217		-2.87349		-3.42881
	$\alpha=10\%$:		$\alpha=10\%$:		$\alpha=10\%$:
	-1.61580		-2.57321		-3.13785

Note. Created using Eviews 10

The calculated values are all below the tabulated values for the three models $\Rightarrow$ the unit root does not exist, and then the series ΔCPI is stationary. Since the hypothesis of existence of a unit root is rejected so the series:

ΔCPI is stationary:

ΔCPI I (0)

INF_CPI is non stationary:

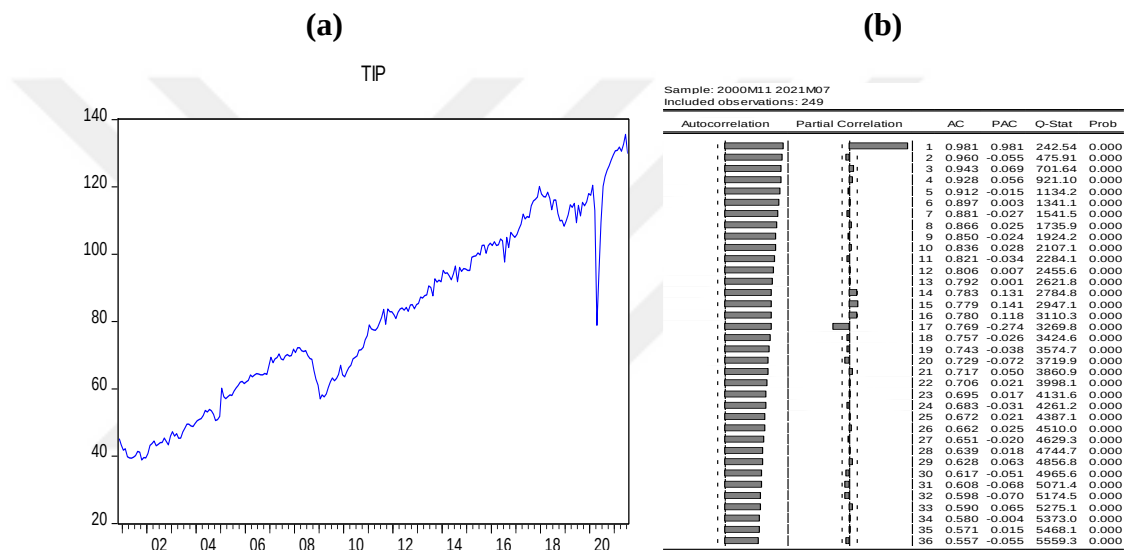
CPI I (1)

Section 3: Stationarity of Total Industrial Production Index (TIP)

1. Graph Analysis

Figure 23

Chart and Correlogram Analysis (TIP)



Note. Created using the Eviews 10

- 1) Figure 23a: Fluctuations of the total industrial production index and an overall upward trend are noticed. The series is non-stationary.
- 2) Figure 23b: The auto correlation function: the terms decrease slowly to 0: which implies that there is trend effect, so TIP Index will not be stationary. The partial auto correlation function: there is a single significant peak, matched to the delay n° 1 AR (1).

2. Augmented Dickey-Fuller test:

Table 27

ADF Test for Total Industrial Production Index

Model [1]		Model [2]		Model [3]	
calculated	tabulated $t_{\hat{\phi}}$	calculated	tabulated $t_{\hat{\phi}}$	calculated	tabulated $t_{\tilde{\phi}}$
$t_{\hat{\phi}}$		$t_{\hat{\phi}}$		$t_{\tilde{\phi}}$	
	$\alpha=1\%:$		$\alpha=1\%:$		$\alpha=1\%:$
1.38483	-2.57432	-0.54495	-3.45662	-4.87619	-3.99549
	$\alpha=5\%:$		$\alpha=5\%:$		$\alpha=5\%:$
	-1.94211		-2.87299		-3.42804
	$\alpha=10\%:$		$\alpha=10\%:$		$\alpha=10\%:$
	-1.61584		-2.57295		-3.13739

Note. Created by Eviews 10

Since the calculated values t_{ϕ} are lower than the tabulated values in model 3, H_0 of existence of a unit root is rejected, TIP Index is stationary. The basic models are as follows: ADF test in model [3]:

$$\Delta \text{TIP}_t = \rho \text{TIP}_{t-1} + c + b t + \lambda_1 \Delta \text{TIP}_{t-1} + \varepsilon_t \quad (1.9)$$

Testing the nullity of the coefficient of the trend. Test of the constant nullity of b by t -statistics test of:

H_0 : $b=0$ the trend is not significant

H_1 : $b \neq 0$ the trend is significant

H_0 is rejected if $T_{\text{Cal}} > T_{\text{Tab}}$

$T_{\text{Cal}}=4.868498 > T_{\text{Tab}}=1,96$, significance of 5%, H_0 is rejected: the trend in this case is significant. Then model (3) is the right model.

Test the existence of a unit root

H_0 : $\Phi = 0$ Existence of a unit root

$H_1 : \Phi < 0$ not existence of a unit root

H_0 is rejected if $ADF_{Cal} > ADF_{Tab}$.

$ADF_{Cal} = -4.876192 > ADF_{Tab} = -3.428049$ at threshold of 5%, H_1 of absence of a unit root is accepted ($0.0004 < 0, 05$).

Test the nullity of the constant

$H_0 : c=0$ absence of the constant

$H_1 : c \neq 0$ existence of the constant

H_0 is rejected if $T_{Cal} > T_{Tab}$

$T_{Cal} = 4.780752 > T_{Tab} = 1,96$ at threshold of 5% so (with prob $0,0000 < 0,05$), H_0 of the absence of the constant is rejected. Consequently, the process generating the series is non-stationary, it is of TS type. Unit root is rejected so a Fisher test of joint hypothesis is constructed: $\rho=0$ and $b=0$

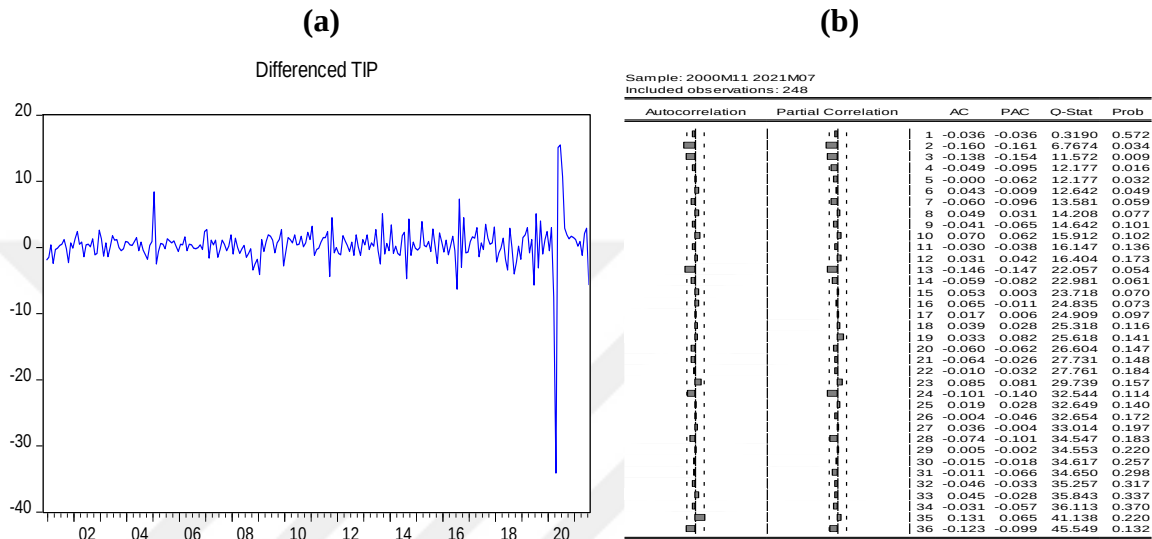
$H_0 : (c, b, \rho) = (c, 0, 0)$

$F_{3, cal} = 12.01333 > F_3$ at 5% reject null hypothesis of trend ($b=0$) conditionally on the absence of a unit root shown in the table. Therefore, model [3] is the right one.

3. Stationarization of the series:

The correct method of Stationarization of the TIP series is to use the first differences to remove the trend:

$$\Delta TIP = TIP - TIP(-1)$$

Figure 24*Chart and Correlogram analysis (ΔTIP)*

Note. Created using Eviews 10

Figure 24a: The series seems stationary because the observations vary around their mean (the series varies around its mean). Figure 24b, from the auto correlation function, it appears that the trend effect is eliminated. So, in general the series is stationary. This conclusion is confirmed by the augmented Dickey-Fuller test.

Table 28*ADF Test for ΔTIP at 5%*

Model 1		Model 2		Model 3	
$t_{\hat{\phi}}$ calculated	$t_{\hat{\phi}}$ tabulated	$t_{\hat{\phi}}$ calculated	$t_{\hat{\phi}}$ tabulated	$t_{\hat{\phi}}$ calculated	$t_{\hat{\phi}}$ tabulated
-15.97719	-1.942115	-11.73375	-2.873142	-11.72970	-3.428273

Note. Created by using Eviews 10

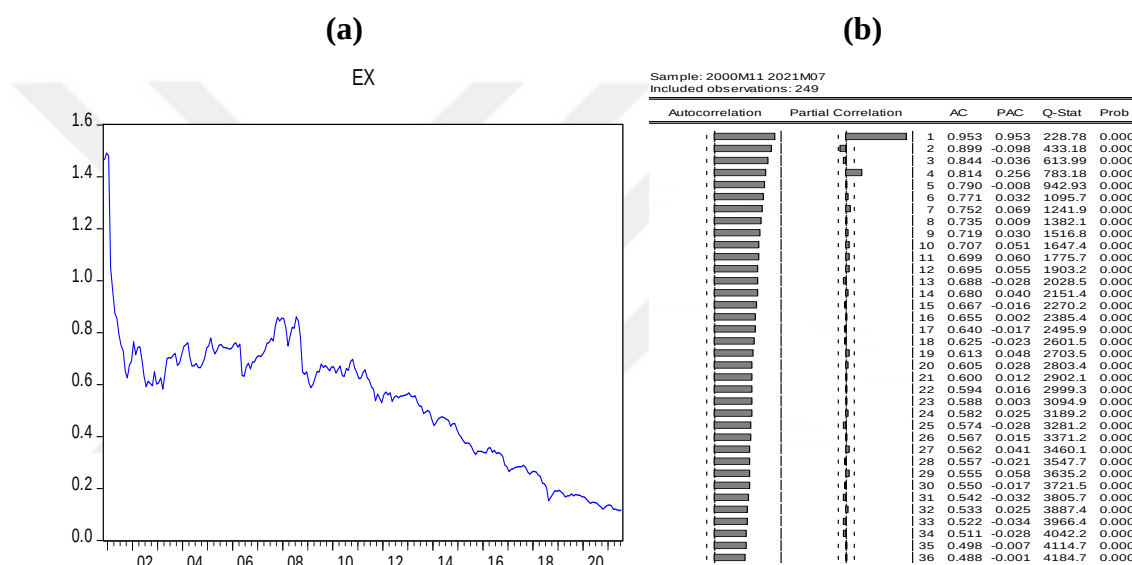
The calculated values are all below the tabulated values for the three models $\Rightarrow$ the unit root does not exist, and then the series ΔTIP is stationary.

Section 4: Stationarity of Nominal Exchange Rate (EX)

1. Graph Analysis

Figure 25

Chart and Correlogram Analysis (EX)



Note. Created using the Eviews 10

- 1) Figure 25a: There are fluctuations of the exchange rate, and an overall downward trend.
- 2) Figure 25b: Auto correlation function: the terms decrease slowly to 0: which implies that there is trend effect, so EX will not be stationary. Partial auto correlation function: there is a single significant peak, matched to the delay n° 1 AR.

2. Augmented Dickey-Fuller test:

Table 29

ADF Test for Exchange Rate

Model [1]		Model [2]		Model [3]	
calculated	tabulated $t_{\hat{\phi}}$	calculated	tabulated $t_{\hat{\phi}}$	calculated	tabulated $t_{\hat{\phi}}$
$t_{\hat{\phi}}$		$t_{\hat{\phi}}$		$t_{\hat{\phi}}$	
	$\alpha=1\%:$		$\alpha=1\%:$		$\alpha=1\%:$
	-2.5743		-3.4566		-3.995
-3.603533	$\alpha=5\%:$	-3.7004	$\alpha=5\%:$	-5.2117	$\alpha=5\%:$
	-1.9421		-2.8729		-3.4280
	$\alpha=10\%:$		$\alpha=10\%:$		$\alpha=10\%:$
	-1.6158		-2.5729		-3.1373

Note. Created by using Eviews 10

The hypothesis that there is a unit root is rejected because the estimated values $t_{\hat{\phi}}$ are more than the tabulated value in absolute terms, and EX is stationary. The basic models are as follows:

ADF test in model [3]:

$$\Delta EX_t = \rho EX_{t-1} + c + b t + \lambda_1 \Delta EX_{t-1} + \varepsilon_t \quad (1.10)$$

Testing the nullity of the coefficient of the trend. Test of the constant nullity of b:

H_0 : $b=0$ the trend is not significant

H_1 : $b \neq 0$ the trend is significant

H_0 is rejected if $T_{Cal} > T_{Tab}$

$T_{Cal} = -3.893067 > T_{Tab} = 1.96$, significance threshold of 5%, H_0 is rejected: the trend is significant. Model (3) is the right model to test the unit root.

Test the existence of a unit root

H_0 : $\Phi = 0$ Existence of a unit root

H_1 : $\Phi < 0$ not existence of a unit root

H_0 is rejected if $ADF_{cal} > ADF_{Tab}$.

$ADF_{cal} = -5.211795 > ADF_{Tab} = -3.428049$ at threshold of 5% therefore H_1 of absence of a unit root is accepted ($0.0001 < 0, 05$).

Test the nullity of the constant

H_0 : $c=0$ absence of the constant

H_1 : $c \neq 0$ existence of the constant

H_0 is rejected if $T_{cal} > T_{Tab}$

$T_{cal} = 4.447566 > T_{Tab} = 1,96$ at threshold of 5% with Prob. ($0,0000 < 0,05$), therefore H_0 of the absence of the constant is rejected. Consequently, the process generating the series is not stationary, it is of TS type. Unit root is rejected so a Fisher test of joint hypothesis is constructed: $\rho=0$ and $b=0$

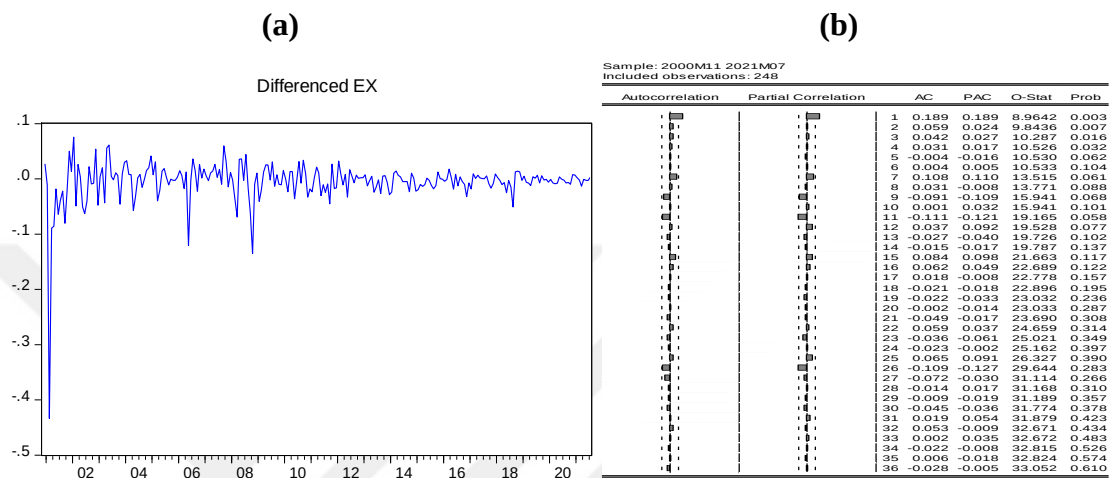
$H_0: (c, b, \rho) = (c, 0, 0)$

$F_{3, cal} = 14.81862 > F_3$ at 5% reject null hypothesis of trend ($b=0$) conditionally on the absence of a unit root shown in the table. Model [3] is the right one.

3. Stationarization of the series:

The correct method of Stationarization of Exchange Rate series is to use the first differences to remove the trend:

$$\Delta EX = EX - EX_{(-1)}$$

Figure 26*Chart and Correlogram analysis (ΔEX)*

Note. Created using Eviews 10

Figure 26a: The series seems stationary because the observations vary around their mean (the series varies around its mean). Figure 26b, from the auto correlation function, it appears that the trend effect is eliminated. So, in general the series is stationary. We confirm this conclusion by the augmented Dickey-Fuller test.

Table 30*ADF Test for ΔEX at 5%*

Model 1		Model 2		Model 3	
$t_{\hat{\phi}}$ calculated	$t_{\hat{\phi}}$ tabulated	$t_{\hat{\phi}}$ calculated	$t_{\hat{\phi}}$ tabulated	$t_{\hat{\phi}}$ calculated	$t_{\hat{\phi}}$ tabulated
-12.73955	-1.942115	-12.94593	-2.873045	-13.03655	-3.428123

Note. Created by using Eviews 10

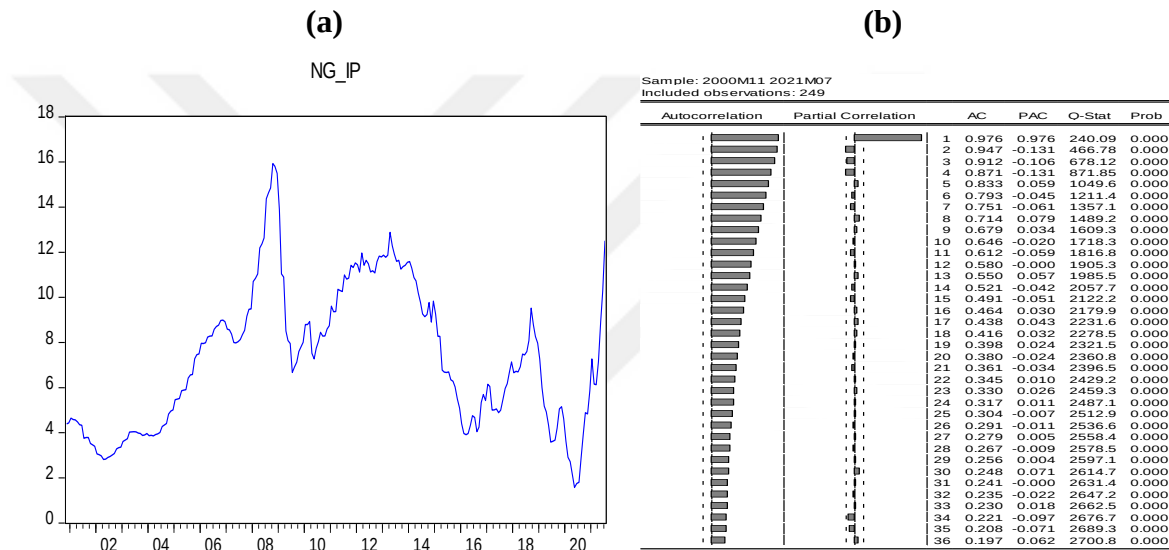
The calculated values are all below the tabulated values for the three models $\Rightarrow$ the unit root does not exist, and then the series ΔEX is stationary.

Section 5: Stationarity of Natural Gas Import Price (NG_IP)

1. Graph Analysis

Figure 27

Chart and Correlogram Analysis (NG_IP)



Note. Created using the Eviews 10

- 1) Figure 27a: Fluctuations of the natural gas import prices and an overall upward trend are noticed.
- 2) Figure 27b: Auto correlation function: terms decrease slowly to 0: which implies that there is trend effect, so NG_IP will not be stationary. Partial auto correlation function: there is a single significant peak, matched to the delay $n^{\circ} 1$ AR (1).

2. Augmented Dickey-Fuller test:

Table 31

ADF Test for Natural Gas Import Price

Model [1]		Model [2]		Model [3]	
calculated	tabulated t_{ϕ}	calculated	tabulated t_{ϕ}	calculated	tabulated t_{ϕ}
t_{ϕ}		t_{ϕ}		t_{ϕ}	
	$\alpha=1\%:$		$\alpha=1\%:$		$\alpha=1\%:$
-0.222496	-2.574474	-2.163695	-3.457061	-2.230755	-3.996113
	$\alpha=5\%:$		$\alpha=5\%:$		$\alpha=5\%:$
	-1.942131		-2.873190		-3.428349
	$\alpha=10\%:$		$\alpha=10\%:$		$\alpha=10\%:$
	-1.615832		-2.573054		-3.137574

Note. Created by using Eviews 10

The calculated values t_{ϕ} are lower than the tabulated value in absolute values, therefore H_0 of existence of a unit root is not rejected, and NG_IP is non stationary. The basic models are as follows:

a. ADF test in model [3]:

$$\Delta \text{NG_IP}_t = \rho \text{NG_IP}_{t-1} + c + b t + \lambda_1 \Delta \text{NG_IP}_{t-1} + \varepsilon_t \quad (1.11)$$

Testing the nullity of the coefficient of the trend. Test of the constant nullity of b:

H_0 : b=0 the trend is not significant

H_1 : b $\neq$ 0 the trend is significant

H_0 is rejected if $T_{\text{Cal}} > T_{\text{Tab}}$

$T_{\text{Cal}}=0.777088 < T_{\text{Tab}}=1, 96$, significance threshold of 5%. Therefore, H_0 of no trend is accepted. Model 3 is not the right model to test the unit root; proceed to model 2.

b. ADF test in the model [2]:

$$\Delta \text{NG_IP}_t = \rho \text{NG_IP}_{t-1} + c + \lambda_1 \Delta \text{NG_IP}_{t-1} + \varepsilon_t \quad (1.12)$$

Test the existence of a unit root

$H_0 : \Phi = 0$ Existence of a unit root

$H_1 : \Phi < 0$ not existence of a unit root

H_0 is rejected if $ADF_{Cal} > ADF_{Tab}$.

$ADF_{Cal} = -2.163695 < ADF_{Tab} = -2.873190$ at threshold of 5% therefore H_0 of existence of a unit root is not rejected ($0.2203 > 0, 05$). Test the nullity of the constant:

$H_0 : c = 0$ absence of the constant

$H_1 : c \neq 0$ existence of the constant

H_0 is rejected if $T_{Cal} > T_{Tab}$

$T_{Cal} = 2.249771 > T_{Tab} = 1,96$ at threshold of 5% with Prob. of ($0,0000 < 0,05$) therefore H_0 of the absence of the constant is rejected. Consequently, the process generating the series is non-stationary, it is of DS type. Unit root is not rejected so a Fisher test of joint hypothesis is constructed: $\rho = 0$ and $b = 0$

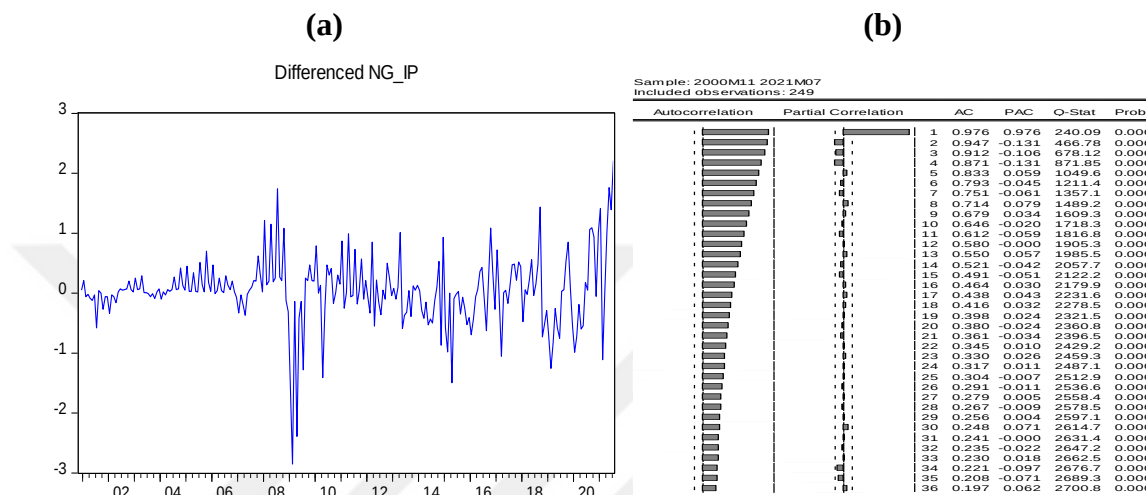
$H_0 : (c, \rho) = (0, 0)$

$F_{2, cal} = 13.62809 > F_2$ at 5% reject null hypothesis of ($c = 0$) conditionally on the presence of a unit root. Model [2] is the right one.

1. Stationarization of the series:

The correct method of Stationarization of NG_IP series is to use the first differences:

$$\Delta NG_IP = NG_IP - NG_IP(-1)$$

Figure 28*Chart and Correlogram analysis (ΔNG_IP)*

Note. Created using Eviews 10

Figure 28a: The series seems stationary because the observations vary around their mean (the series varies around its mean). Figure 28b, from the auto correlation function, it appears that the trend effect is eliminated. So, in general the series is stationary. This conclusion is confirmed by the augmented Dickey-Fuller test.

Table 32*ADF Test for ΔNG_IP at 5%*

Model 1		Model 2		Model 3	
$t_{\hat{\phi}}$ calculated	$t_{\hat{\phi}}$ tabulated	$t_{\hat{\phi}}$ calculated	$t_{\hat{\phi}}$ tabulated	$t_{\hat{\phi}}$ calculated	$t_{\hat{\phi}}$ tabulated
-5.266475	-1.942131	-5.281617	-2.873190	-5.247630	-3.428349

Note. Created by using Eviews 10

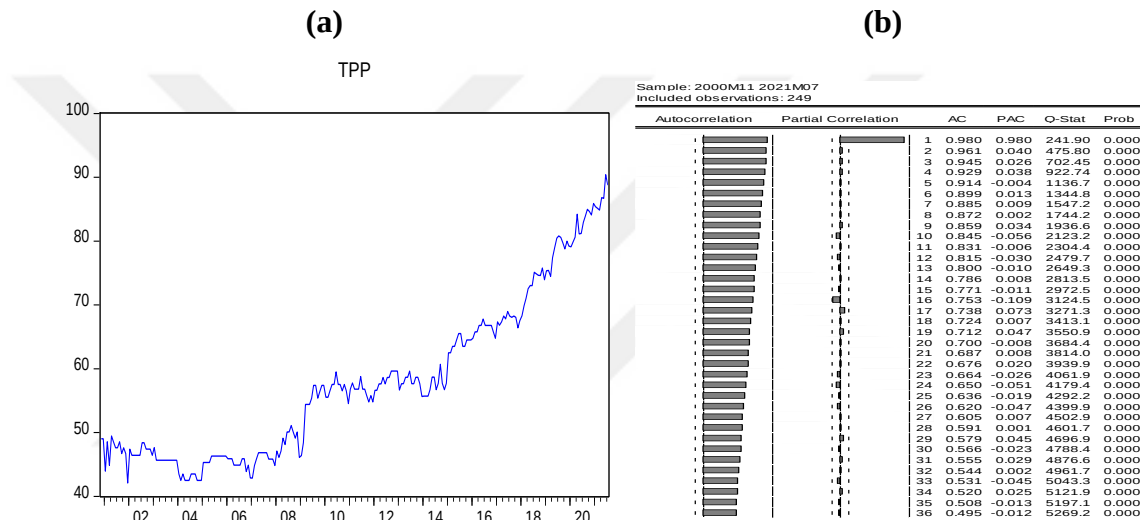
The calculated values are all below the tabulated values for the three models $\Rightarrow$ the unit root does not exist, and then the series ΔNG_IP is stationary.

Section 6: Stationarity of Total Petroleum and Other Liquids Production (TPP)

1. Graph Analysis

Figure 29

Chart and Correlogram Analysis (TPP)



Note. Created using the Eviews 10

- 1) Figure 29a: Fluctuations of the total petroleum and other liquid production and an overall upward trend are noticed.
- 2) Figure 29b: Auto correlation function: terms decrease slowly to 0: which implies that there is trend effect, so TPP will not be stationary. Partial auto correlation function: there is a single significant peak, matched to the delay n° 1 AR (1).

2. Augmented Dickey-Fuller test:

Table 33

ADF Test for Total Petroleum and Other Liquids Production

Model [1]		Model [2]		Model [3]	
calculated	tabulated t_{ϕ}	calculated	tabulated t_{ϕ}	calculated	tabulated t_{ϕ}
t_{ϕ}		t_{ϕ}		t_{ϕ}	
	$\alpha=1\%:$		$\alpha=1\%:$		$\alpha=1\%:$
	-2.574320	0.662308	-3.456622	-2.495797	-3.995492
1.855041	$\alpha=5\%:$		$\alpha=5\%:$		$\alpha=5\%:$
	-1.942110		-2.872998		-3.428049
	$\alpha=10\%:$		$\alpha=10\%:$		$\alpha=10\%:$
	-1.615846		-2.572951		-3.137397

Note. Created by using Eviews 10

The calculated values t_{ϕ} are lower than the tabulated values in absolute values, therefore H_0 of existence of a unit root is not rejected, and then TPP is non-stationary. The basic model is as follow:

ADF test in model [3]:

$$\Delta \text{TPP}_t = \rho \text{TPP}_{t-1} + c + b t + \lambda_1 \Delta \text{TPP}_{t-1} + \varepsilon_t \quad (1.13)$$

Testing the nullity of the coefficient of the trend. Test of the constant nullity of b:

H_0 : $b=0$ the trend is not significant

H_1 : $b \neq 0$ the trend is significant

H_0 is rejected if $T_{\text{Cal}} > T_{\text{Tab}}$

$T_{\text{Cal}}=2.953320 > T_{\text{Tab}}=1,96$, significance threshold of 5%. H_0 is rejected: the trend in this case is significant. Then model (3) is the right model.

Test the existence of a unit root

H_0 : $\Phi = 0$ Existence of a unit root

H_1 : $\Phi < 0$ not existence of a unit root

H_0 is rejected if $ADF_{cal} > ADF_{Tab}$

$ADF_{cal} = -2.495797 < ADF_{Tab} = -3.428049$ at threshold of 5%, H_1 of absence of a unit root is rejected (0.33 < 0, 05).

Test the nullity of the constant

H_0 : $c=0$ absence of the constant

H_1 : $c \neq 0$ existence of the constant

H_0 is rejected if $T_{cal} > T_{Tab}$

$T_{cal} = 2.287351 > T_{Tab} = 1,96$ at threshold of 5% with Prob. of (0, 023 < 0, 05) therefore H_0 of the absence of the constant is rejected. Consequently, the process generating the series is non-stationary, it is of TS type. Unit root is not rejected so a Fisher test of joint hypothesis is constructed: $\rho = 0$ and $b = 0$

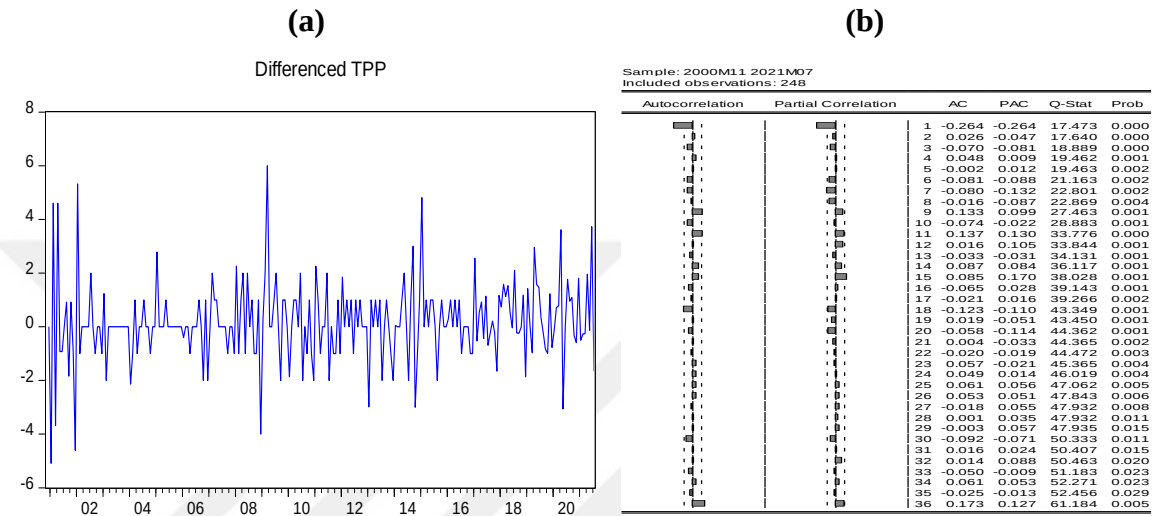
$H_0: (c, b, \rho) = (c, 0, 0)$

$F_{3, cal} = 4.587259 > F_3$ at 5% reject null hypothesis of trend ($b = 0$) conditionally on the presence of a unit root. Model [2] is the right one.

3. Stationarization of the series:

The correct method of Stationarization of TPP series is to use the first differences:

$$\Delta TPP = TPP - TPP(-1)$$

Figure 30*Chart and Correlogram analysis (ΔTPP)*

Note. Created using Eviews 10

The series seems stationary because the observations vary around their mean (the series varies around its mean). Moreover, from the auto correlation function, it appears that the trend effect is eliminated. So, in general the series is stationary. This conclusion is confirmed by the augmented Dickey-Fuller test.

Table 34*ADF Test for ΔTPP at 5%*

Model 1		Model 2		Model 3	
t_{ϕ} calculated	t_{ϕ} tabulated	t_{ϕ} calculated	t_{ϕ} tabulated	t_{ϕ} calculated	t_{ϕ} tabulated
-20.17043	-1.942115	-20.47562	-2.873045	-20.77690	-3.428123

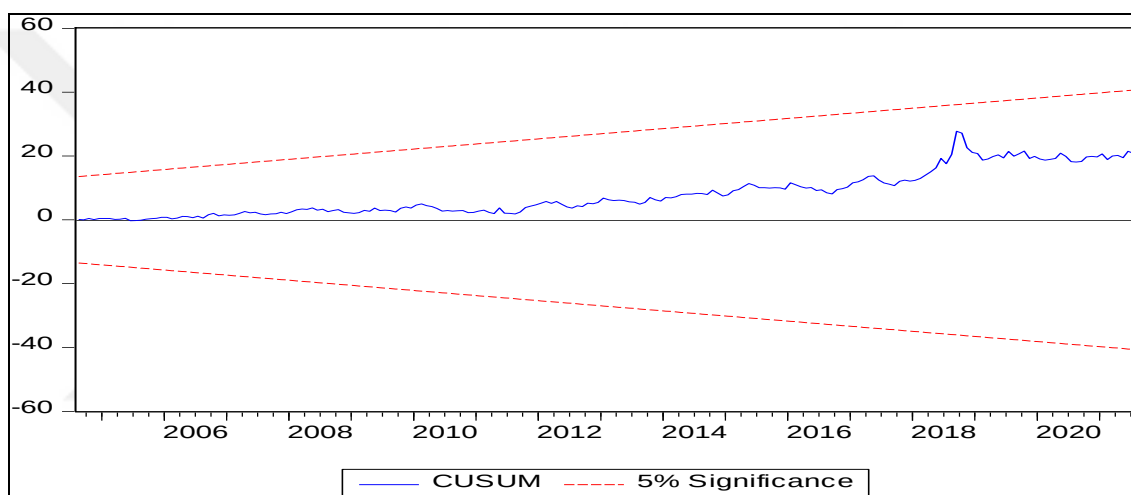
Note. Created by using Eviews 10. The calculated values are all below the tabulated values for the three models $\Rightarrow$ the unit root does not exist, and then the series ΔTPP is stationary.

Appendix B: Study of the Stability of the ARDL Models by CUSUM Test

Figure 31 illustrates how the CPI ARDL model is stable by laying between the 15 percent boundaries.

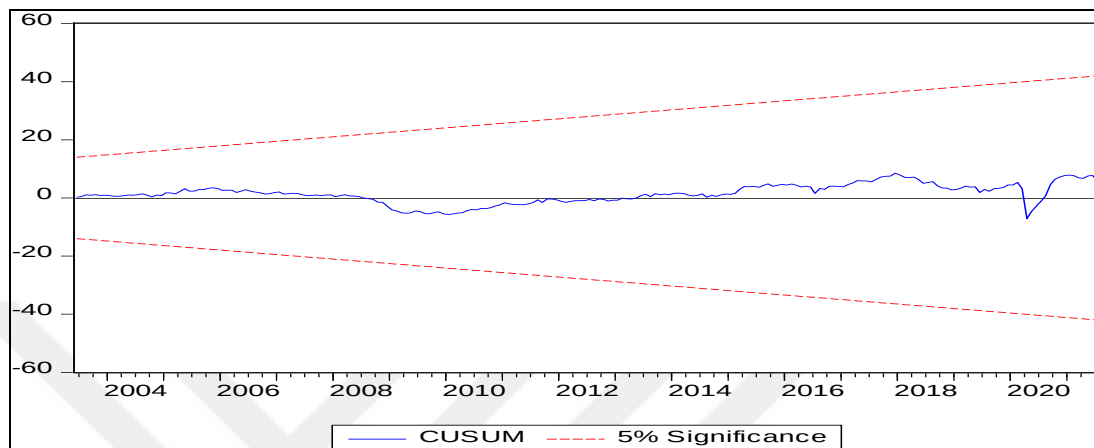
Figure 31

Cusum Test for Stability of CPI Model



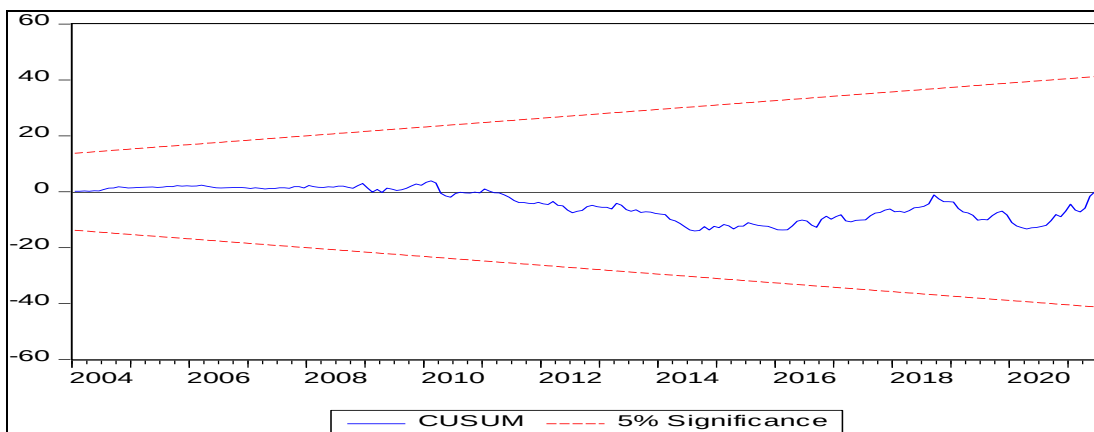
Note. Created by Eviews 10

Figure 32 illustrates how the TIP ARDL model is stable by laying between the 15 percent boundaries.

Figure 32*Cusum Test for Stability of TIP Model*

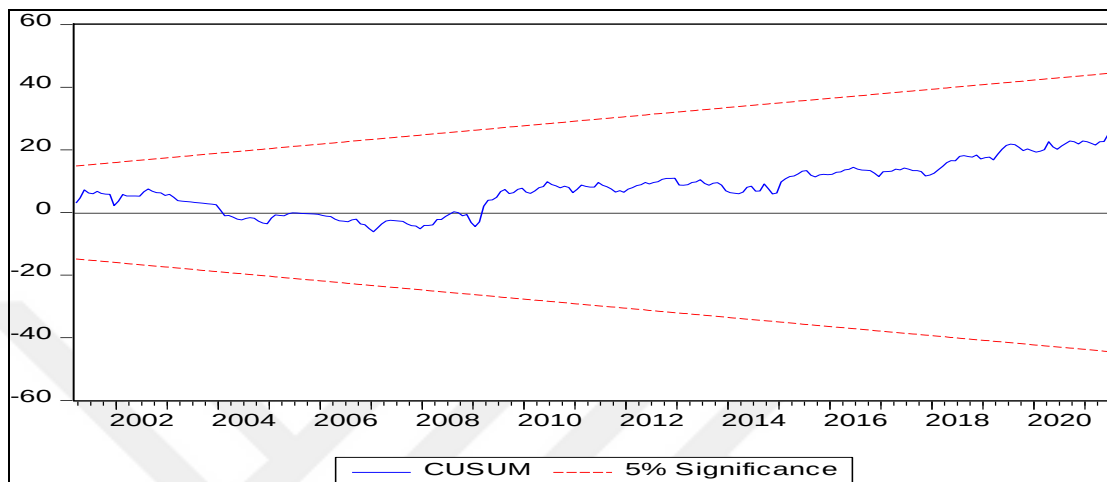
Note. Created by Eviews 10

Figure 33 illustrates how the NG-IP ARDL model is stable by laying between the 15 percent boundaries.

Figure 33*Cusum Test for Stability of NG_IP Model*

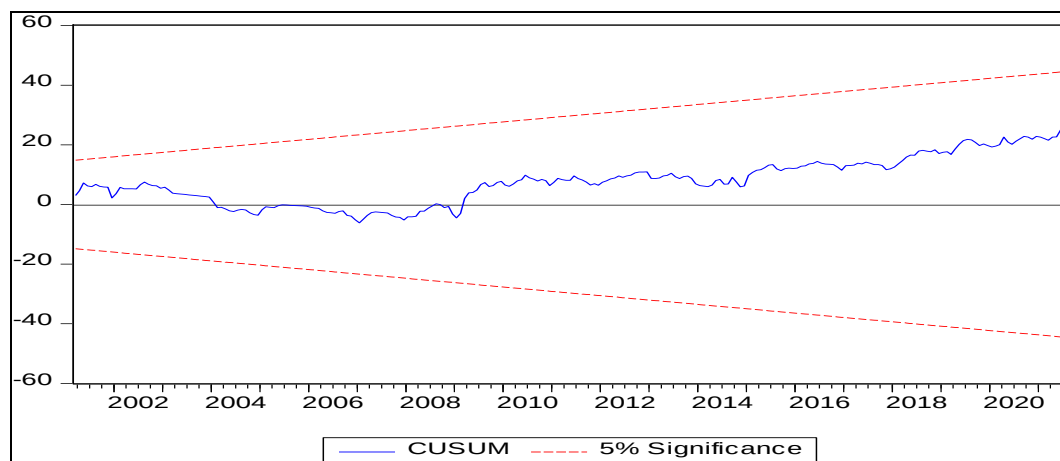
Note. Created by Eviews 10

Figure 34 illustrates how the TPP ARDL model is stable by laying between the 15 percent boundaries.

Figure 34*Cusum Test for Stability of TPP Model*

Note. Created by using Eviews

Figure 35 illustrates how the EX-model is stable by laying between the 15 percent boundaries.

Figure 35*Cusum Test for Stability of EX (TRY/USD) Model*

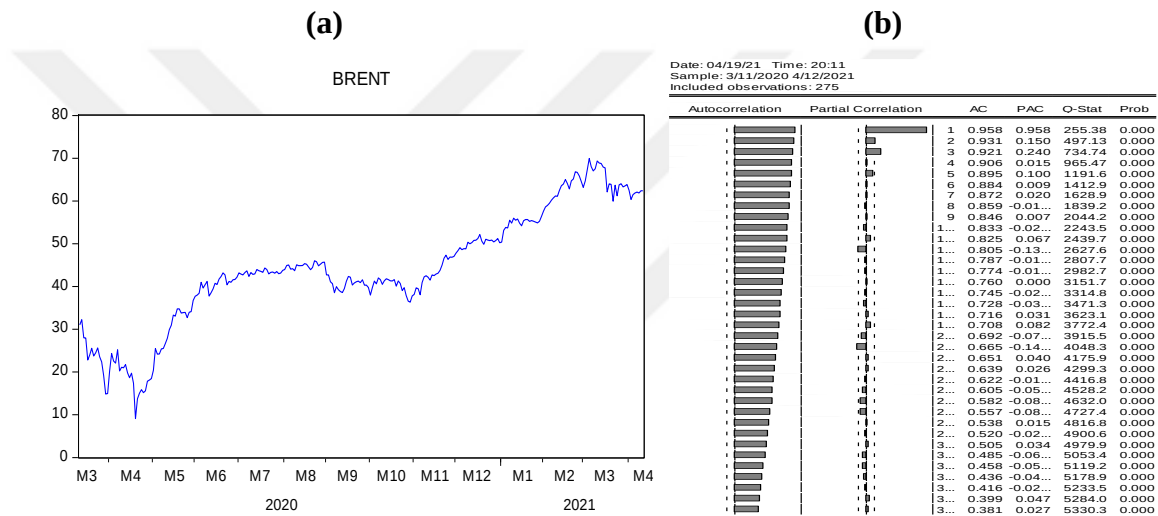
Note. Created by using Eviews 10

Appendix C: Study of the Stationarity of COVID-19 and Stock and Energy Indicators

Section 1: Study of Daily Brent Oil Price Series Stationarity

Figure 36

Chart and Correlogram Analysis (Brent oil price)



Note. Created using Eviews 10

Figure 36a had an upward trend. In Correlogram 36b, the autocorrelation function: the terms decrease slowly to 0: which implies that there is trend effect, so the price of oil will not be stationary. The partial auto correlation function: there is a single significant peak, matched to the delay n° 1 AR (1). The optimal number of lags is p=1 by using AIC criteria which is (3.593420).

Table 35*ADF test for Brent Oil price*

Model [1]		Model [2]		Model [3]	
Calculated $t_{\hat{\phi}}$	tabulated $t_{\hat{\phi}}$	calculated $t_{\hat{\phi}}$	tabulated $t_{\hat{\phi}}$	calculated $t_{\hat{\phi}}$	tabulated $t_{\hat{\phi}}$
	$\alpha=1\%:$		$\alpha=1\%:$		$\alpha=1\%:$
	-2.573188		-3.453400		-3.990935
-1.05473	$\alpha=5\%:$	-0.56739	$\alpha=5\%:$	-2.47059	$\alpha=5\%:$
	-1.941953		-2.871582		-3.425841
	$\alpha=10\%:$		$\alpha=10\%:$		$\alpha=10\%:$
	-1.615948		-2.572193		-3.136094

Note. Created using Eviews 10.

Table 35 showed that the calculated values $t_{\hat{\phi}}$ is higher than all the tabulated values, so H_0 is accepted, the variable Brent oil price is non-stationary. The basic model is as follows:

ADF test in model [3]:

$$\Delta \text{brent_op}_t = \rho \text{brent_op}_{t-1} + c + bt + \lambda_1 \Delta \text{brent_op}_{t-1} + \varepsilon_t \quad (3.1)$$

Testing the nullity of the coefficient of the trend. Test of the constant nullity of b:

H_0 : $b=0$ the trend is not significant

H_1 : $b \neq 0$ the trend is significant

H_0 is rejected if $T_{\text{Cal}} > T_{\text{Tab}}$

$T_{\text{Cal}}=2.452539 > T_{\text{Tab}}=1,96$, significance threshold of 5%, therefore H_0 is rejected: The trend in this case is significant. Then model (3) is the right model.

Test the existence of a unit root

H_0 : $\rho = 0$ Existence of a unit root

H_1 : $\rho < 0$ not existence of a unit root

H_0 is rejected if $ADF_{\text{Cal}} > ADF_{\text{Tab}}$

$ADF_{Cal} = -2.470596 < ADF_{Tab} = -3.425841$ at significant level of 5%, H_0 of existence of a unit root is not rejected.

Test the nullity of the constant

H_0 : $c=0$ absence of the constant

H_1 : $c \neq 0$ existence of the constant

H_0 is rejected if $T_{Cal} > T_{Tab}$

$T_{Cal} = 2.319024 > T_{Tab} = 1.96$ at threshold of 5%, H_0 of the absence of the constant is rejected. Consequently, the process generating the series is non-stationary, it is of TS type. Unit root is not rejected so a Fisher test of joint hypothesis is constructed: $\rho = 0$ and $b = 0$ $H_0: (c, b, \rho) = (c, 0, 0)$. $F_{3, cal} = 2.557174 > F_3$ at 5% reject null hypothesis of trend ($b = 0$) conditionally on the presence of a unit root shown in the table. So, model [3] is the right one.

Stationarization of the series:

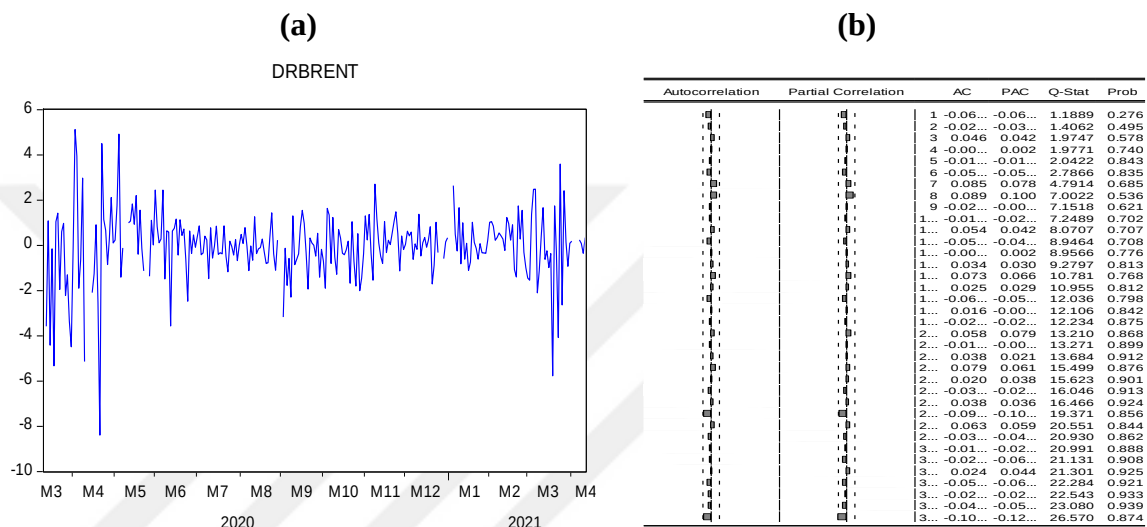
Take the first difference of the new series

$$\Delta \text{brent_op} = \text{brent_op} - \text{brent_op}(-1)$$

- Chart analysis: ($\Delta \text{Brent_op}$ stationary series):

Figure 37

Chart and Correlogram Analysis ($\Delta \text{Brent_op}$)



Note. Created using Eviews 10

In Figure 37a, the series seems stationary because the observations vary around their mean. Figure 37b, in the Correlogram the auto correlation function appears that the trend effect is eliminated. So, in general the series is stationary. This conclusion is confirmed by the augmented Dickey-Fuller test.

Table 36*ADF test on the series $\Delta \text{brent_op}$*

Model [1]		Model [2]		Model [3]	
t-cal	t-tab	t-cal	t-tab	t-cal	t-tab
	$\alpha=1\%$:		$\alpha=1\%$:		$\alpha=1\%$:
-10.81796	-2.575326	-10.76799	-3.459494	-8.007025	-3.991412
	$\alpha=5\%$:		$\alpha=5\%$:		$\alpha=5\%$:
	-1.942249		-2.874258		-3.426073
	$\alpha=10\%$:		$\alpha=10\%$:		$\alpha=10\%$:
	-1.615755		-2.573625		-3.136231

Note. Created using Eviews 10

The calculated values are all below the tabulated values for the three models $\Rightarrow$ the unit root does not exist, and then the series $\Delta \text{brent_op}$ is stationary. Since the hypothesis of existence of a unit root is rejected so the series

$\Delta \text{brent_op}$ is stationary:

$\Delta \text{brent_op} \sim I(0)$

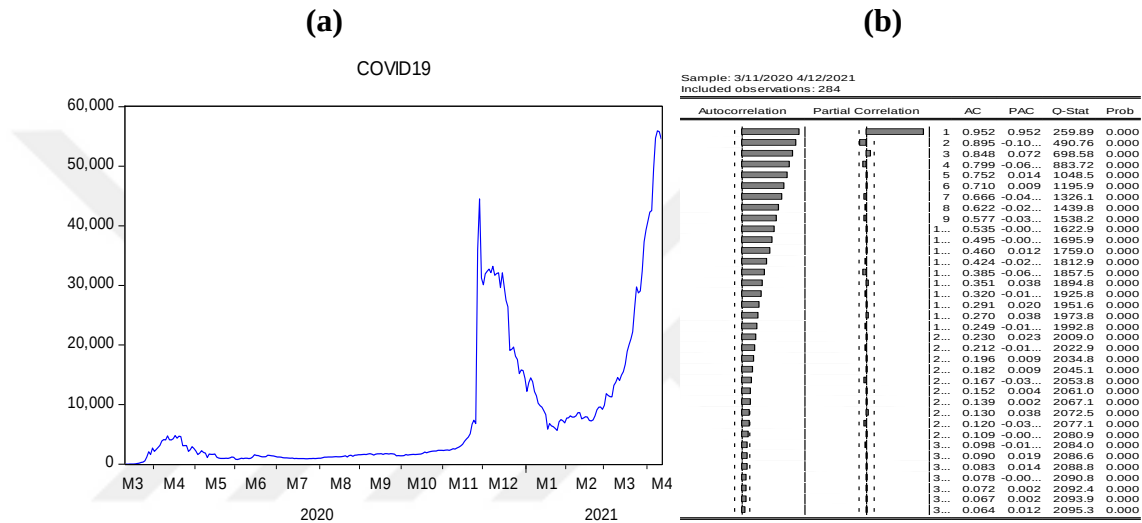
brent_op is non-stationary:

$\text{brent_op} \sim I(1)$

Section 2: Study of Number of Infected Cases of COVID-19 Series Stationary

Figure 38

Chart and Correlogram Analysis (COVID-19)



Note. Created using Eviews 10

In Figure 38a shows an upward trend. Figure 38b, the autocorrelation function: the terms decrease slowly to 0: which implies that there is trend effect, so the number of infected will not be stationary. The partial auto correlation function: there is a single significant peak, matched to the delay $n^{\circ} 1$ AR (1). The lags of $p = 8$ with the minimum value of AIC criteria = 18.12699.

Table 37*ADF Test for COVID-19*

Model [1]		Model [2]		Model [3]	
calculated $t_{\hat{\phi}}$	tabulated $t_{\hat{\phi}}$	calculated $t_{\hat{\phi}}$	tabulated $t_{\hat{\phi}}$	calculated $t_{\hat{\phi}}$	tabulated $t_{\hat{\phi}}$
	$\alpha=1\%:$		$\alpha=1\%:$		$\alpha=1\%:$
	-2.573367		-3.453910		-3.991292
-0.338323	$\alpha=5\%:$	-0.344608	$\alpha=5\%:$	-1.540600	$\alpha=5\%:$
	-1.941965		-1.941978		-3.426191
	$\alpha=10\%:$		$\alpha=10\%:$		$\alpha=10\%:$
	-1.615940		-1.615931		-3.136196

Note. Created using Eviews 10

In the Table 37, the calculated values $t_{\hat{\phi}}$ are higher than all the tabulated values, so H_0 of existence of a unit root is accepted, the number of infected cases is non-stationary. The basic models are as follows:

ADF test in model [3]:

$$\Delta \text{COVID-19}_t = \rho \text{ COVID-19}_{t-1} + c + b t + \lambda_1 \Delta \text{COVID-19}_{t-1} + \varepsilon_t \quad (3.2)$$

Testing the nullity of the coefficient of the trend. Test of the constant nullity of b:

H_0 : $b=0$ the trend is not significant

H_1 : $b \neq 0$ the trend is significant

H_0 is rejected if $T_{\text{Cal}} > T_{\text{Tab}}$

$T_{\text{Cal}}=2.063941 > T_{\text{Tab}}=1,96$, significance threshold of 5%, H_0 is rejected: the trend in this case is significant. Then model (3) is the right model.

Test the existence of a unit root

H_0 : $\rho = 0$ Existence of a unit root

H_1 : $\rho < 0$ not existence of a unit root

H_0 is rejected if $\text{ADF}_{\text{Cal}} > \text{ADF}_{\text{Tab}}$

$ADF_{Cal} = -1.540600 < ADF_{Tab} = -2.871693$ at threshold of 5% therefore H_0 of existence of a unit root is not rejected.

Test the nullity of the constant

H_0 : $c=0$ absence of the constant

H_1 : $c \neq 0$ existence of the constant

H_0 is rejected if $T_{Cal} > T_{Tab}$

$T_{Cal} = -1.056485 < T_{Tab} = 1.96$ at threshold of 5% therefore H_0 of the absence of the constant is not rejected. Consequently, the process generating the series is non-stationary, it is TS type. Unit root is not rejected so a Fisher test of joint hypothesis is constructed: $\rho = 0$ and $b = 0$

$H_0: (c, b, \rho) = (c, 0, 0)$

where, $F_{3, cal} = 7.811160 > F_3$ at 5% reject null hypothesis of trend ($b = 0$) conditionally on the presence of a unit root shown in the table. the model [3] is the right one.

Stationarization of the series:

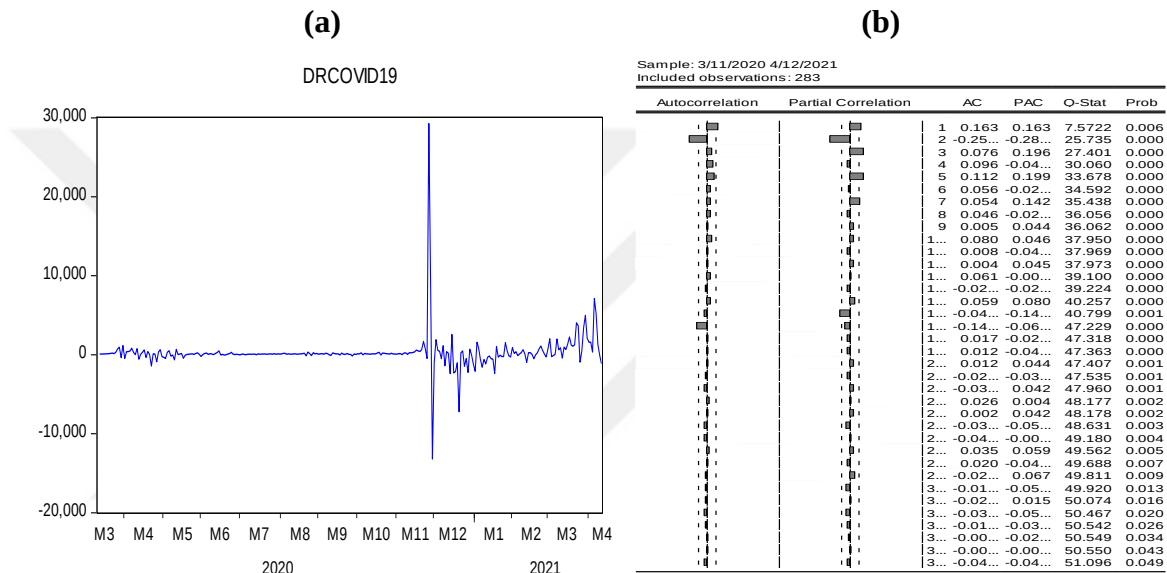
The correct method of Stationarization of the COVID-19 series is to use the first differences:

$$\Delta \text{COVID-19} = \text{COVID-19} - \text{COVID-19}(-1)$$

- *Graph Analysis:*

Figure 39

Chart and Correlogram Analysis (Δ COVID-19)



Note. Created using Eviews 10

In Figure 39a, the series seems stationary because the observations vary around their mean. Figure 39b, in the Correlogram the auto correlation function appears that the trend effect is eliminated. So, in general the series is stationary. This conclusion is confirmed by the augmented Dickey-Fuller test.

Table 38

ADF Test for Δ COVID-19

	ADF _{Cal}	ADF _{Tab}		
		1%	5%	10%
Model (3)	-6.036154	-3.991412	-3.426073	-3.136231

Note. Created by using Eviews 10

The calculated value is below the tabulated values for all three significant levels in Table 38 $\Rightarrow$ the unit root does not exist, and then the series $\Delta\text{COVID-19}$ is stationary. Since the hypothesis of existence of a unit root is rejected so the series:

$\Delta\text{COVID-19}$ is stationary:

$$\Delta\text{COVID-19} \sim I(0)$$

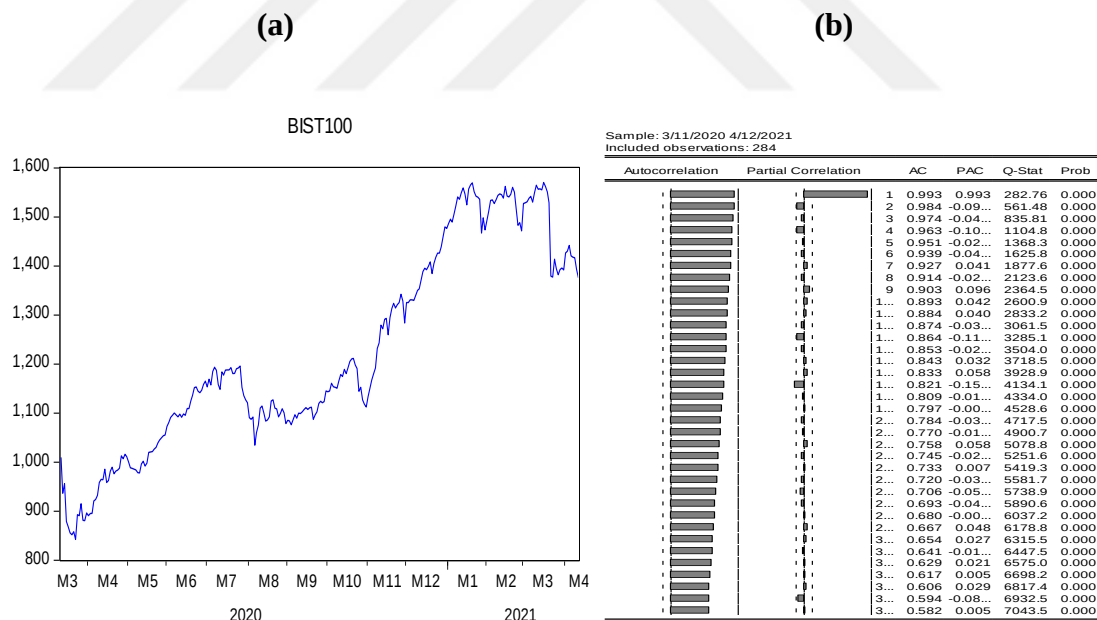
COVID-19 is non stationary:

$$\text{COVID-19} \sim I(1)$$

Section 3: Study of Borsa Istanbul Index (BIST-100) Series Stationarity

Figure 40

Chart and Correlogram Analysis (BIST-100)



Note. Created using Eviews 10

In Figure 40a, fluctuations of BIST-100 index and an overall upward trend is noticed. In Figure 40b, Correlogram, autocorrelation function: the terms decrease slowly to 0: which implies that there is trend effect, so BIST-100 will not be stationary. The partial

autocorrelation function: there is a single significant peak, matched to the delay $n^\circ 1$ AR (1). With lowest value of AIC criteria = 8.692489 at the lag $p = 1$.

Table 39

ADF Test for BIST-100 Index

Model [1]		Model [2]		Model [3]	
Calculated	Tabulated	calculated	tabulated	calculated	tabulated
$t_{\hat{\phi}}$	$t_{\hat{\phi}}$	$t_{\hat{\phi}}$	$t_{\hat{\phi}}$	$t_{\hat{\phi}}$	$t_{\hat{\phi}}$
	$\alpha=1\%$:		$\alpha=1\%$:		$\alpha=1\%$:
	-2.573277		-3.453652		-3.991292
1.219313	$\alpha=5\%$:	-1.641657	$\alpha=5\%$:	-1.578487	$\alpha=5\%$:
	-1.941965		-2.871693		-3.426014
	$\alpha=10\%$:		$\alpha=10\%$:		$\alpha=10\%$:
	-1.615940		-2.572253		-3.136196

Note. Created by using Eviews 10

In the Table 39, the calculated values $t_{\hat{\phi}}$ are higher than all the tabulated values, so H_0 of existence of a unit root is accepted; BIST-100 is non-stationary. The basic models are as follows:

ADF test in model [3]:

$$\Delta \text{BIST100}_t = \rho \text{BIST100}_{t-1} + c + b t + \lambda_1 \Delta \text{BIST100}_{t-1} + \varepsilon_t \quad (3.3)$$

Testing the nullity of the coefficient of the trend. Test of the constant nullity of b :

H_0 : $b=0$ the trend is not significant

H_1 : $b \neq 0$ the trend is significant

H_0 is rejected if $T_{\text{Cal}} > T_{\text{Tab}}$

$T_{\text{Cal}}=1.057592 < T_{\text{Tab}}=1,96$, significance threshold of 5%, H_1 is rejected: the trend in this case is insignificant. Then model (3) is not the right model.

Test the existence of a unit root

H_0 : $\Phi = 0$ Existence of a unit root

$H_1 : \Phi < 0$ not existence of a unit root

H_0 is rejected if $ADF_{Cal} > ADF_{Tab}$

We have $ADF_{Cal} = -1.578487 < ADF_{Tab} = -3.426014$ at threshold of 5%, therefore H_0 is not rejected.

Test the nullity of the constant

$H_0 : c=0$ absence of the constant

$H_1 : c \neq 0$ existence of the constant

H_0 is rejected if $T_{Cal} > T_{Tab}$

$T_{Cal} = -1.852240 < T_{Tab} = 1.96$ at threshold of 5% therefore H_0 of the absence of the constant is not rejected. Consequently, the process generating the series is non-stationary, it is of DS type. Unit root is not rejected so a Fisher test of joint hypothesis is constructed: $\rho = 0$ and $b = 0$

$H_0 : (c, b, \rho) = (c, 0, 0)$

$F_{3, cal} = 0.717789 < F_3$ at 5% don't reject null hypothesis of trend ($b = 0$) conditionally on the presence of a unit root shown in the table. So, model [3] is not the right one; proceed to model [2].

ADF test in the model [2]:

$$\Delta BIST100_t = \rho BIST100_{t-1} + c + \lambda_1 \Delta BIST100_{t-1} + \varepsilon_t \quad (3.4)$$

Test the nullity of the constant: $t_{cal} = 1.8716 < t_{tab} = 1.96$ at 5%; thus, don't reject the null of the constant ($c = 0$) conditionally on the presence of a unit root shown in the table. So, model [2] is not the right one; proceed to model [1].

ADF test for model [1]:

$$\Delta BIST100_t = \rho BIST100_{t-1} + \lambda_1 \Delta BIST100_{t-1} + \varepsilon_t \quad (3.5)$$

Borsa Istanbul Index is non-stationary of DS type without drift.

Stationarization of the series:

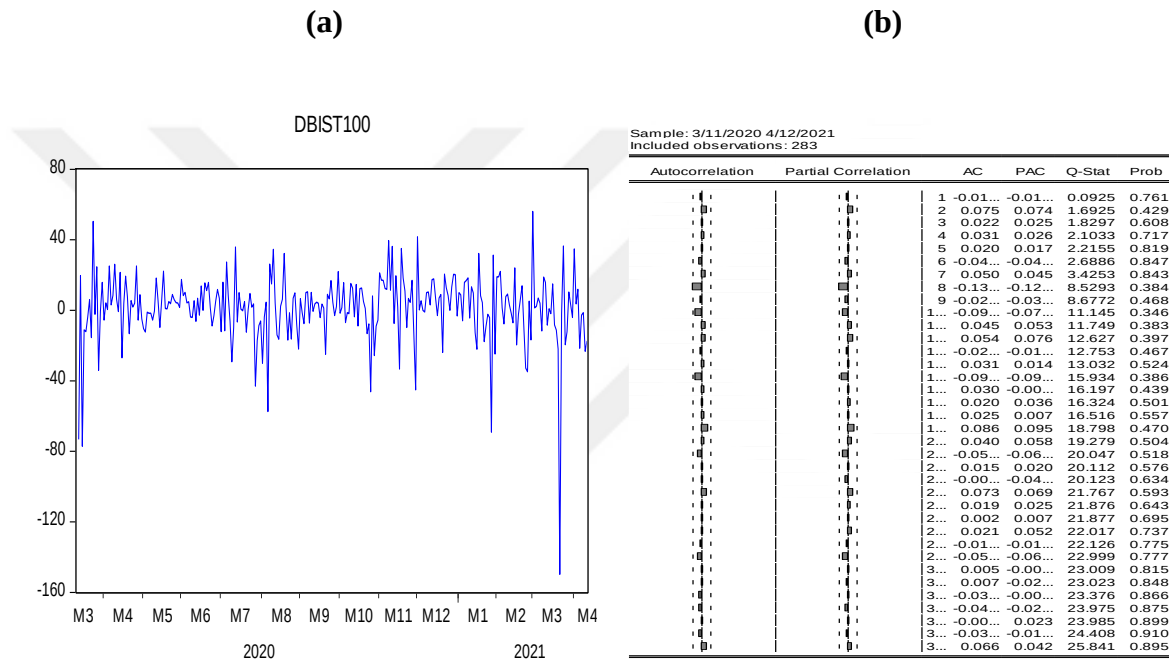
The correct method of Stationarization of the BIST-100 series is to use the first differences:

$$\Delta BIST100 = BIST100 - BIST100 (-1)$$

- *Graph Analysis:*

Figure 41

Chart and Correlogram Analysis (Δ BIST-100)



Note. Created using Eviews 10

In Figure 41a, the series seems stationary because the observations vary around their mean. Figure 41b, in the Correlogram the auto correlation function appears that the trend effect is eliminated. So, in general the series is stationary. This conclusion is confirmed by the augmented Dickey-Fuller test.

Table 40*ADF Test for $\Delta BIST-100$*

	ADF_{cal}	ADF_{tab}		
		1%	5%	10%
Model 1	-12.04896	-2.573337	-1.941974	-1.615934

Note. Created using Eviews 10

The calculated value is below the tabulated values for the model in Table 40 $\Rightarrow$ the unit root is not existing, and then the series $\Delta BIST-100$ is stationary. Since the hypothesis of existence of a unit root is rejected, so the series:

$\Delta BIST-100$ is stationary

$\Delta BIST-100 \sim I(0)$

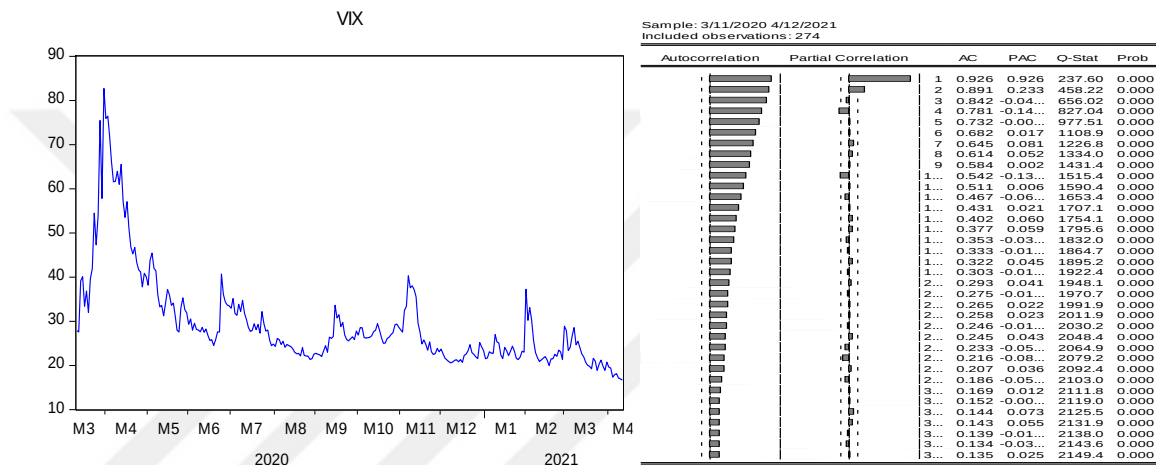
$BIST-100$ is non-stationary

$BIST-100 \sim I(1)$

Section 4: Study of the Volatility of Stock Price Index (VIX) Series Stationarity

Figure 42

Chart and Correlogram Analysis (VIX)



Note. Created using Eviews 10

In the Chart 42a, fluctuations of VIX and an overall downward trend is noticed. In Correlogram 42b, autocorrelation function: terms decrease slowly to 0: which implies that there is trend effect, so VIX will not be stationary. The partial autocorrelation function: there is a single significant peak, matched to the delay n° 1 AR (1). The number of lags is P=8 by minimum AIC criteria = 5.145517.

Table 41*ADF Test for VIX Index*

Model [1]		Model [2]		Model [3]	
calculated $t_{\hat{\phi}}$	tabulated $t_{\hat{\phi}}$	calculated $t_{\hat{\phi}}$	tabulated $t_{\hat{\phi}}$	calculated $t_{\hat{\phi}}$	tabulated $t_{\hat{\phi}}$
	$\alpha=1\%:$		$\alpha=1\%:$		$\alpha=1\%:$
-1.207179	-2.573367	-2.289051	-3.453910	-3.406733	-3.991656
	$\alpha=5\%:$		$\alpha=5\%:$		$\alpha=5\%:$
	-1.941978		-2.871806		-3.426191
	$\alpha=10\%:$		$\alpha=10\%:$		$\alpha=10\%:$
	-1.615931		-2.572313		-3.136301

Note. Created using Eviews 10 software

In the Table 41, the calculated values $t_{\hat{\phi}}$ are higher than all the tabulated values, so H_0 of existence of a unit root is accepted, VIX is non-stationary. The basic models are as follows: ADF test in model [3]:

$$\Delta VIX_t = \rho VIX_{t-1} + c + b t + \lambda_1 \Delta VIX_{t-1} + \varepsilon_t \quad (3.6)$$

Testing the nullity of the coefficient of the trend. Test of the constant nullity of b:

H_0 : b=0 the trend is not significant

H_1 : b $\neq$ 0 the trend is significant

H_0 is rejected if $T_{Cal} > T_{Tab}$

$T_{Cal} = 2.503841 > T_{Tab} = 1.96$, significance threshold of 5%, H_0 is rejected: the trend in this case is significant. Then model (3) is the right model to test the unit root.

Test the existence of a unit root

H_0 : $\Phi = 0$ Existence of a unit root

H_1 : $\Phi < 0$ not existence of a unit root

H_0 is rejected if $ADF_{Cal} > ADF_{Tab}$.

$ADF_{Cal} = -3.406733 < ADF_{Tab} = -3.426191$ at threshold of 5%, the hypothesis H_0 of existence of a unit root is not rejected.

Test the nullity of the constant

H_0 : $c=0$ absence of the constant

H_1 : $c \neq 0$ existence of the constant

H_0 is rejected if $T_{Cal} > T_{Tab}$

$T_{Cal}=3.165120 > T_{Tab}=1,96$ at threshold of 5% therefore H_0 of the absence of the constant is rejected. Consequently, the process generating the series is non-stationary, it is TS type.

Unit root is not rejected so a Fisher test of joint hypothesis is constructed: $\rho=0$ and $b=0$

$H_0:(c, b, \rho) = (c, 0, 0)$

$F_{3, cal}= 9.004502 > F_3$ at 5% reject null hypothesis of trend ($b=0$) conditionally on the presence of a unit root shown in the table. So, model [3] is the right one.

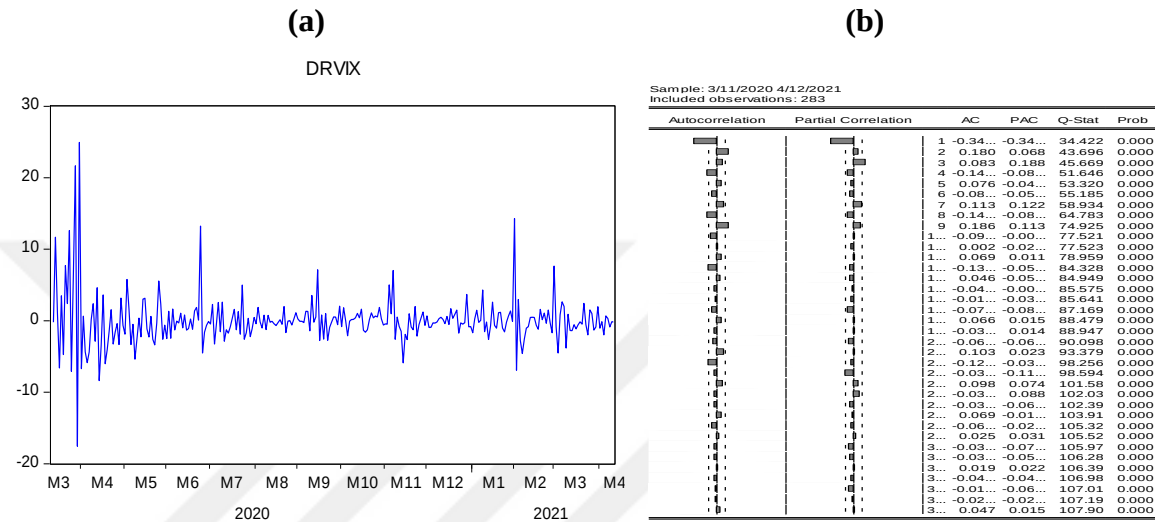
Stationarization of the series:

The correct method of Stationarization of the VIX series is to use the first differences:

$$\Delta VIX = VIX - VIX(-1)$$

- *Graph analysis (ΔVIX series):*

In the Chart 43, the series seems stationary because the observations vary around their mean. Moreover, in the Correlogram the autocorrelation function appears that the trend effect is eliminated. So, in general the series is stationary. This conclusion is confirmed by the augmented Dickey-Fuller test.

Figure 43*Chart and Correlogram Analysis (ΔVIX)*

Note. Created using Eviews 10

Table 42*ADF Test for ΔVIX*

	ADF_{Cal}	ADF_{Tab}		
		1%	5%	10%
Model 3	-7.603147	-3.991412	-3.426073	-3.136231

Note. Created using the Eviews 10

The calculated value is below the tabulated values for the model in Table 42 $\Rightarrow$ the unit roots do not exist, and then the series ΔVIX is stationary. Since the hypothesis of existence of a unit root is rejected.

Appendix D: Sample List of Symbols / Abbreviations

- VAR: Vector Autoregressive Model
- ECM: Error Correction Model
- ARDL: Autoregressive Distributed Lag Model
- VIX: Volatility of Stock Price Index
- BIST-100: Borsa Istanbul Index
- WHO: World Health Organization
- CPI: Consumer Price Index
- COVID-19: Coronavirus Disease of 2019
- PP: Phillips-Perron
- DSGE: Dynamic Stochastic General Equilibrium
- CGE: Computable General Equation
- MSCS: Morgan Stanley Capital International
- LNG: Liquid Natural Gas
- EMRA: Energy Market Regulatory Authority
- BCM: Billion Cubic Meters
- GDPA: General Directorate of Petroleum Affairs
- MENR: Ministry of Energy and Natural Resources
- MEUP: Ministry of Environment and Urban Planning
- MFLS: Ministry of Family Labor and Social Security
- OECD: Organization for Economic Co-operation and Development
- IMF: International Monetary Fund
- GCC: Gulf Co-operation Council
- IFS: International Financial System
- OPEC: Organization of the Petroleum Exporting Countries
- CEIC: Census and Economic Information Center
- IEA: International Energy Agency
- WTI: West Texas Intermediate Oil
- WPI: Whole Price Index

- GARH: Generalized Autoregressive Conditional Heteroscedasticity
- Y – Real income
- O – Oil
- R - Resource transfer
- r – Raw material
- M – Imports
- P – Oil prices
- m - Manufacturing
- Δ_t denotes change in economic indicators
- β_0 is the intercept of the line on Y-axis.
- B denotes the slope co-efficient
- Brent-OP denotes Brent oil price.
- NG-IP denotes natural gas import price
- EX denotes nominal exchange rate
- CPI denotes consumer price index
- TPP denotes total petroleum and other liquids production
- TIP denotes total industrial production index
- i is the maximum number of lags
- ECT: error correction term which is the adjustment speed parameter
- ε_t is residual term of the model representing all other factors that influence total industrial production index that have not been included in the model.
- SCR_3 : Sum of squared residuals from the regression of on c, t, x_{t-1} increased terms
- x_{t-1} : Sum of squared residuals from the regression of Δx_t on just c and augmented terms Δx_{t-1}
- K: number of explanatory variables constant included in the unconstrained model.
T: the number of observations used in the regression.
- C = number of parameters will be estimated in the VAR.
- SCRR: residuals of constrained model.
- SCRU: residuals of unconstrained model

- Σ_{RVAR} : variance covariance matrix of residual constrained model
- Σ_{UVAR} : variance covariance matrix of residual unconstrained model
- N: observation number.

