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Master's Thesis

Analysis of crude oil commodity in Iran

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Thesis title

Analysis of crude oil commodity in Iran

Objectives of thesis

Iran's economy highly depends on crude oil exports. Some factors affect the Iranian oil market. This diploma thesis aims to investigate the factors that play the role in Iran oil exportation and analyze how Iran's economy is affected by the oil market.

Methodology

The diploma thesis consists of two parts, theoretical and analytical.

The theoretical part includes describing the oil market in general and the Iran petroleum industry.

In the analytical parts, the dependency of Iran's economy on oil is investigated, which include quantitative analysis of the Iran oil market and its economy by econometric modelling.

The proposed extent of the thesis

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Keywords

Economic Analysis, OPEC, Econometrics, Oil price

Recommended information sources

Farzanegan, M. R., & Markwardt, G. (2009). The effects of oil price shocks on the Iranian economy,. Energy Economics, 31(1), 134-151.

Kallis, G., & Sager, J. (2017). Oil and the economy: A systematic review of the literature for ecological economists. Ecological Economics, 561-571.

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Nademi, Y. (2018). The resource curse and income inequality in Iran. Qual Quant, 52, 1159–1172.

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Declaration

I declare that I have worked on my master's thesis titled " Analysis of crude oil commodity in Iran" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the master's thesis, I declare that the thesis does not break any copyrights.

In Prague on date of submission ___________________01.04.2023_________

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Analysis of crude oil commodity in Iran

Abstract
This thesis analysed the impact of oil export revenue on Iran's GDP and external debt, as well as the role of sanctions in this relationship. Quantitative methodologies, including multivariate regression analysis, Vector Autoregression (VAR), and Vector Error Correction Model (VECM), were used to examine the dynamic interactions between the variables. Time-series analysis was also conducted to investigate the trends and patterns in Iran's oil export revenue, GDP, and external debt. Qualitative methodologies, including a literature review was used to explore the political and economic implications of sanctions on Iran's oil export revenue, GDP, and external debt. Data was collected from various sources, such as the Central Bank of Iran, the World Bank, and the International Monetary Fund (IMF).

The findings indicated that there is a significant positive relationship between Iran's oil export revenue and GDP in the long run. However, this relationship is weaker in the short run, indicating that shocks to the system can have an impact on the relationship. Additionally, the analysis showed that external debt has a negative impact on Iran's GDP. The role of sanctions in the relationship between oil export revenue, GDP, and external debt was also examined, revealing that sanctions have a significant negative impact on Iran's economy. Impulse Response Function (IRF) analysis showed that the impact of a shock to oil export revenue on GDP decreases over time, indicating that the Iranian economy has some degree of resilience to oil shocks. Overall, this thesis provides a comprehensive analysis of the economic challenges facing Iran, specifically regarding oil export revenue, GDP, and external debt.

Keywords: regression analysis, oil export, GDP, Vector Autoregressive Model, OPEC

Analýza komodity surové ropy v Íránu.

Abstrakt
Tato práce analysovala vliv exportních příjmů z ropy na HDP a zahraniční dluh Íránu, stejně jako roli sankcí v této vztahové dynamice. K kvantitativním metodologiím patřila analýza multivariační regrese, vektorová autoregrese (VAR) a vektorový model korekce chyb (VECM) k prozkoumání dynamických interakcí mezi proměnnými. Byla také provedena analýza časových řad ke zkoumání trendů a vzorců v exportních příjmech z ropy, HDP a zahraničním dluhu Íránu. Kvalitativní metodologie, včetně revize literatury, byla použita ke zkoumání politických a ekonomických dopadů sankcí na exportní příjmy z ropy, HDP a zahraniční dluh Íránu. Data byla shromážděna z různých zdrojů, jako je Centrální banka Íránu, Světová banka a Mezinárodní měnový fond (MMF). Výsledky naznačily, že mezi exportními příjmy z ropy a HDP existuje signifikantní pozitivní vztah na dlouhé časové období. Nicméně tento vztah je v krátkodobém horizontu slabší, což naznačuje, že otřesy v systému mohou mít vliv na vztah. Analýza také ukázala, že zahraniční dluh má negativní vliv na HDP Íránu. Byla zkoumána také role sankcí v této vztahové dynamice mezi exportními příjmy z ropy, HDP a zahraničním dluhem, což ukázalo, že sankce mají významný negativní dopad na ekonomiku Íránu. Analýza funkce odezvy na impuls (IRF) ukázala, že vliv šoku na exportní příjmy z ropy na HDP se s časem snižuje, což naznačuje, že íránská ekonomika má určitou odolnost vůči šokům z ropy. Celkově tato práce poskytuje komplexní analýzu ekonomických výzev, kterým čelí Írán, zejména pokud jde o exportní příjmy z ropy, HDP a zahraniční dluh.

Klíčová slova: regresní analýza, export ropy, HDP, vektorový autoregresní model, OPEC

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1 Introduction

Iran is one of the world's leading oil-producing countries, with vast reserves of oil and gas. Iran's economy is heavily reliant on its oil exports, and any changes in its oil exports can significantly impact its GDP and external debt. The country has been subject to economic sanctions, which have limited its oil exports and made it challenging to manage its economy effectively. Therefore, this research aims to investigate the relationship between Iran's oil exports, GDP, and external debt by using univariate and multivariate regression models.

Iran has a long history of oil production and exports, which has been a vital component of its economy since the early 20th century. Iran has the fourth-largest proven crude oil reserves in the world and is the second-largest producer of crude oil among OPEC countries. However, Iran's economy has been struggling due to the imposition of economic sanctions by the United States and other countries. These sanctions have severely impacted Iran's oil exports and have caused significant economic challenges for the country.

The problem is that the impact of Iran's oil exports on its GDP and external debt has not been studied comprehensively, and the current understanding of this relationship is limited. Furthermore, there is a lack of research on the effects of economic sanctions on Iran's oil exports, GDP, and external debt.

The primary aim of this research is to investigate the relationship between Iran's oil exports, GDP, and external debt using univariate and multivariate regression models, including VAR, VECM, and impulse response functions. The specific research questions are:

- What is the relationship between Iran's oil exports and GDP?
- What is the relationship between Iran's oil exports and external debt?
- How do economic sanctions impact Iran's oil exports, GDP, and external debt?
- What is the short- and long-term impact of changes in Iran's oil exports on its GDP and external debt?

This research will contribute to the existing literature on the relationship between oil exports, GDP, and external debt in Iran. It will provide policymakers with a better understanding of the impact of oil exports on Iran's economy and the effects of economic sanctions. The findings of this research can also inform future policy decisions regarding the management of Iran's oil exports, GDP, and external debt.

There are several limitations to this study, including data availability, data quality, and the complexity of the Iranian economy. The data used in this research is limited to secondary sources, and the accuracy of the data is subject to limitations. Additionally, the Iranian economy is a complex system with many factors influencing its performance, which may not be fully captured in this research.

The methodology employed in the study is thoroughly explained in chapter 2, with both univariate and multivariate regression techniques used to analyze the data. The theoretical part in chapter 3, provides a historical overview of the oil industry in Iran, explores the significance of the sector to the economy, and examines various economic concepts such as Dutch disease. The practical part of the research in chapter 4, presents the results of the regression analyses, as well as the use of VAR, VECM, and orthogonal impulse response analysis to explore the relationship between the oil sector and the Iranian economy. Finally, the thesis concludes with a discussion of the findings and their implications for future research in this area in chapter 5 and 6.

2 Objectives and Methodology

2.1 Objectives

This thesis explores the relationship between oil export revenue, external debt, and GDP in Iran. Specifically, this study investigates the impact of changes in oil export revenue and external debt on Iran's GDP. This thesis aims to answer the research question: What is the impact of oil export revenue and external debt on Iran's GDP? This research question is essential for Iran, a significant oil-exporting country grappling with economic challenges for several years. Iran's economy is heavily dependent on oil exports, which account for a significant portion of its GDP. Moreover, the country has been facing economic sanctions that have considerably impacted its economy, making it crucial to understand the relationship between oil export revenue, external debt, and GDP.

2.2 Methodology

In this thesis, various methodologies will be used to analyse the impact of oil export revenue on Iran's GDP and external debt and the role of sanctions in this relationship. Quantitative and qualitative methods will be employed to achieve the research objectives. The multivariate regression analysis will examine the relationship between Iran's oil export revenue, GDP, and external debt. Specifically, a regression model will be run with Iran's GDP as the dependent variable and oil export revenue and external debt as independent variables. The natural logarithm of the variables will be used to control for the possibility of non-linear relationships between the variables. Additionally, Vector Autoregression (VAR) and Vector Error Correction Model (VECM) will be used to analyse the dynamic interactions between the variables.

Time-series analysis will also investigate the trends and patterns in Iran's oil export revenue, GDP, and external debt. Time-series plots, autocorrelation and partial autocorrelation functions, and unit root tests will be examined to check for the stationarity of the variables.

Moreover, Impulse Response Functions (IRFs) will be utilized to assess the influence of oil export revenue on Iran's GDP and external debt in both the short and long term. IRFs help examine the dynamic interactions between the variables by illustrating how shocks in one variable affect the others over time.

By using IRFs, the scale and duration of the effects of oil export revenue on Iran's GDP and external debt can be determined, as well as how these effects evolve. This analysis will provide a more comprehensive understanding of the impact of oil export revenue on Iran's economy, which will help policymakers make informed decisions about economic policies and development strategies.

To examine the impact of sanctions on the Iranian economy and its oil export revenue, GDP, and external debt, a comprehensive literature review will be conducted. Official reports and statements from international organizations such as the US U.S. Department of the Treasury and the United Nations (UN) will also be analysed to gain a deeper understanding of the effects of sanctions on Iran's economy.

Data will be collected from various sources, such as the Annual Statistical Bulletin of OPEC. Publicly available datasets from reputable sources, such as the United Nations

Conference on Trade and Development (UNCTAD), will also be used to supplement the analysis.
The combination of quantitative and qualitative methodologies will provide a comprehensive analysis of the impact of oil export revenue on Iran's GDP and external debt and the role of sanctions in this relationship. The analysis will offer valuable insights into Iran's economic challenges and contribute to the existing literature on the subject. Also, the SAS® OnDemand for Academics is used for modelling purposes provided by the University of life sciences.

2.2.1 Univariate regression

Univariate regression is a statistical method used to examine the relationship between one dependent variable and one independent variable. This thesis uses univariate regression to analyse the relationship between Iran's GDP and oil export revenue.
The regression model used in this study will have Iran's GDP as the dependent variable and oil export revenue as the independent variable. The model will be designed to test the hypothesis that a significant positive relationship exists between Iran's oil export revenue and GDP.
The model will be run using an appropriate regression algorithm, such as ordinary least squares (OLS). The goodness of fit will be evaluated using R-squared, adjusted R-squared, and mean squared error (MSE). The analysis results will be interpreted to assess the direction and strength of the relationship between Iran's GDP and oil export revenue.

2.2.2 Multivariate regression

Multivariate regression is a statistical method used to examine the relationship between two or more dependent variables and one or more independent variables. This thesis uses multivariate regression to analyse the relationship between Iran's oil export revenue, GDP, and external debt.
In this study, the multivariate regression analysis will be conducted using Vector Autoregression (VAR), Vector Error Correction Model (VECM), and Impulse Response Analysis.

2.2.2.1 VAR

VAR (Vector Autoregression) is a statistical model that analyses the dynamic interactions between two or more time series. The VAR model is commonly used in macroeconomics, finance, and international trade to analyse the dynamic relationship between economic variables, such as exchange rates, interest rates, and commodity prices.
(Wooldridge, 2012) explains the VAR model, its assumptions, and how to estimate it using statistical software such as SAS (Inc., 2014).
The VAR model is a system of equations where each variable is expressed as a function of its past values and the past values of the other variables in the system. The model captures the short-run dynamics between the variables while maintaining the long-run equilibrium relationship between them.
To estimate a VAR model using SAS, one can use the VARMAX procedure. The VARMAX procedure allows for the estimation of vector autoregressive moving-average (VARMA) models, which are a generalization of the VAR model that allows for the inclusion of moving-average terms.

To estimate a VAR model using SAS, one needs to specify the number of lags to include in the model and the order of the autoregressive polynomial. The VARMAX procedure also allows for the inclusion of exogenous variables in the model.
Once the model is estimated, one can use the VARMAX procedure to obtain impulse response functions, which show how shocks to one variable affect the others over time. The VARMAX procedure also allows for estimating forecasted values of the variables in the system based on past data.
In this study, VAR will analyse the dynamic relationship between Iran's oil export revenue, GDP, and external debt.
The VAR model will be designed to test the hypothesis that there is a significant relationship between Iran's oil export revenue, GDP, and external debt. The model will be run using an appropriate regression algorithm, such as OLS, and the goodness of fit will be evaluated using measures such as R-squared, adjusted R-squared, and MSE. The analysis results will be interpreted to assess the direction and strength of the relationship between Iran's oil export revenue, GDP, and external debt.

2.2.2.2 Impulse response function

Impulse Response Analysis is a statistical tool used to analyse the dynamic response of one variable to an impulse or shock in another variable over time. In this study, Impulse Response Analysis will analyse the dynamic impact of Iran's oil export revenue on its GDP and external debt.
The Impulse Response Analysis will be designed to test the hypothesis that Iran's oil export revenue has a significant short- and long-term impact on its GDP and external debt. The analysis will be conducted by using VAR or VECM models to estimate the impulse response functions. The magnitude and duration of the effects of oil export revenue on Iran's GDP and external debt will be identified and analysed, providing a more comprehensive understanding of the impact of oil export revenue on Iran's economy.
The Impulse Response Analysis will be conducted using an appropriate software like SAS. The results will be interpreted to assess the dynamic impact of Iran's oil export revenue on its GDP and external debt. The results will be presented in graphs and tables, illustrating the short- and long-term responses of GDP and external debt to changes in oil export revenue.

2.2.2.3 Cointegration Analysis

"Cointegration" is a statistical concept introduced by Clive Granger and Robert Engle in the early 1980s to analyse the long-run relationship between non-stationary time series. In (Wooldridge, 2012), cointegration is defined as "a linear combination of two or more variables that has a lower-order integration process than each variable individually."
VECM is a statistical model that analyses the dynamic relationship between non-stationary time series. In this study, VECM will analyse the dynamic relationship between Iran's oil export revenue, GDP, and external debt.
The VECM model will be designed to test the hypothesis that a significant long-run relationship exists between Iran's oil export revenue, GDP, and external debt. The model will be run using an appropriate regression algorithm, such as OLS, and the goodness of fit will be evaluated using measures such as R-squared, adjusted R-squared, and MSE. The analysis results will be interpreted to assess the direction and strength of the long-run relationship between Iran's oil export revenue, GDP, and external debt.

3 Theoretical Part

3.1 History of oil in Iran

Oil has played a significant role in shaping Iran's history, beginning with the discovery of oil in southwestern Iran in 1908 by a team sponsored by the visionary English entrepreneur, William Knox D'Arcy. As a result, D'Arcy became the director of the Anglo-Persian Oil Company (APOC), which later evolved into British Petroleum (BP) that we know today. The APOC, predominantly run by British engineers and managers, controlled Iran's oil industry for the following five decades, reaping most of the profits for their endeavors (Foltz, 2016).

(Elm, 1992)explores the historical context and consequences of the nationalization of Iran's oil industry in the 1950s. The author argues that the nationalization was a critical event in Iran's political and economic history, with far-reaching implications for the country and the wider region.

Elm begins by providing a historical overview of Iran's oil industry, highlighting the dominance of foreign powers, particularly the British, in the country's oil sector. The author explains that Iran's decision to nationalize the Anglo-Iranian Oil Company (AIOC) in 1951 was driven by a desire for greater economic sovereignty and a fair share of the profits from the country's natural resources.

Elm argues that the nationalization of the oil industry had significant political consequences, both domestically and internationally. Domestically, the move was a catalyst for Iranian nationalism, which had been suppressed under foreign domination. The author also notes that the nationalization was a crucial factor in the rise of Mohammad Mossadegh, who became Iran's prime minister in 1951 and championed the cause of economic nationalism.

Internationally, the nationalization of Iran's oil industry had far-reaching implications, with the British and the United States intervening to protect their interests. Elm argues that the intervention was not merely about oil, but also reflected broader geopolitical considerations, such as the fear of Soviet expansion in the region.

Elm concludes by discussing the aftermath of the nationalization, which saw the overthrow of Mossadegh in a CIA-backed coup in 1953 and the reinstatement of the Shah. The author argues that the coup had long-term consequences for Iran, with the Shah's authoritarian rule leading to a period of political repression and economic stagnation. Elm suggests that the nationalization of Iran's oil industry represented a missed opportunity for the country to chart an independent path to economic development, and instead, it fell victim to the geopolitical interests of foreign powers.

Overall, Elm's paper provides a comprehensive and insightful analysis of the nationalization of Iran's oil industry and its consequences. The author's arguments are supported by a wealth of historical evidence, making the paper a valuable contribution to the scholarship on the topic. Elm's work highlights the importance of understanding the historical context of Iran's oil industry and its role in shaping the country's political and economic destiny.

(Fesharaki, 1974) provides an insightful historical overview of the Iranian oil industry from its inception to the early 1970s. The author delves into the economic, political, and social factors that shaped the industry and its impact on Iran's economy.

The paper highlights the role of British Petroleum (BP) and the Anglo-Persian Oil Company (APOC) in the development of the Iranian oil industry. The APOC controlled the industry until the Iranian government's nationalization in 1951, and BP became the majority shareholder after the merger with the APOC. The author discusses how the British government and BP had significant influence over the Iranian government and the oil industry, and the terms of the agreements between the Iranian government and BP were highly favorable to the latter.

The paper also examines the impact of the Iranian oil industry on the country's economy and social structure. The author notes that the industry brought significant economic benefits, generating employment opportunities, and contributing to the country's GDP. However, the benefits were not distributed evenly, and the gap between the wealthy and the poor widened. Additionally, the oil industry's dominance hindered the development of other sectors, such as agriculture and manufacturing. Fesharaki's paper provides a detailed account of the Iranian oil industry's evolution from a colonial enterprise to a critical component of the country's economy. The author examines the nationalization of the industry and its impact on the Iranian economy and international relations. The paper highlights the challenges that the Iranian government faced in asserting control over the industry and the complex relationships with international oil companies and foreign governments.

In conclusion, Fesharaki's paper is an excellent resource for understanding the Iranian oil industry's development and its impact on Iran's economy and society. The author provides a detailed account of the industry's history, covering various economic and political factors, and the changing dynamics between Iran and international oil companies. Overall, the paper is a valuable contribution to the scholarship on the Iranian oil industry and provides an excellent foundation for further research on the topic.

(Mohaddes & Pesaran, 2013) examine the relationship between oil income and economic growth in Iran from 1900 to 2010. The authors argue that although oil revenue has played a significant role in Iran's economic development, it has also had a destabilizing effect on the economy due to its volatility and susceptibility to fluctuations in global oil prices. The authors use a variety of statistical methods to analyse the relationship between oil income and economic growth, including a dynamic panel model that accounts for endogeneity, heterogeneity, and cross-sectional dependence. They find that oil income has a positive effect on economic growth in the short run but can have negative long-term effects on economic growth due to Dutch disease effects, rent-seeking behavior, and institutional weaknesses. Moreover, the authors argue that Iran's heavy reliance on oil exports has resulted in a lack of diversification in the economy, making it vulnerable to fluctuations in global oil prices. This, in turn, has contributed to economic instability, inflation, and unemployment. The authors also examine the impact of oil income on government spending and find that oil revenue has contributed to increased government spending, but that this spending has not necessarily translated into improved economic outcomes. Overall, the authors conclude that oil income has been both a blessing and a curse for the Iranian economy. While it has contributed significantly to economic growth and development, it has also created economic instability and dependence on a single commodity. To mitigate these challenges, the authors suggest policies that promote economic diversification, improve the efficiency of the oil sector, and enhance the quality of institutions and governance.

All three articles reviewed discuss the history of the oil industry in Iran and its impact on the country's economy and political landscape. They also touch upon the nationalization of the oil industry in Iran and its consequences. However, they differ in their focus and approach.

Elm focuses primarily on the nationalization of the oil industry in Iran in the 1950s and the resulting power struggle between Iran and Britain. The paper provides a detailed analysis of the events leading up to the nationalization and the aftermath, including the negotiations, the embargo on Iranian oil, and the arbitration proceedings. Fesharaki provides a historical overview of the Iranian oil industry, including its evolution from its beginnings in 1901 to the early 1970s. The paper discusses the impact of oil revenues on the Iranian economy and the state of the domestic distribution network.
Mohaddes and Pesaran research provides a comprehensive analysis of the relationship between oil revenues and economic growth in Iran over the past century. The paper examines the three sub-periods of Iran's economic growth and the role of oil revenues in each period. The authors also explore the challenges and risks associated with Iran's dependence on oil exports and propose strategies for ensuring sustainable economic growth.
Overall, the three articles complement each other by providing different perspectives and insights into the complex history of the oil industry in Iran and its impact on the country's economy and politics.

3.2 Importance of the oil sector in the Iranian economy

The Middle East is renowned for its abundant oil reserves, which have played a critical role in shaping the global energy landscape for several decades. The pie chart in Figure 3-1 presented in this thesis vividly illustrates the distribution of crude oil reserves among different OPEC countries in the Middle East in 2021. The chart's findings are quite revealing, with Saudi Arabia emerging as the most significant holder of crude oil reserves, accounting for a whopping 30% of the total reserves in the region. This fact emphasizes the Kingdom's dominance in the global oil market and the critical role it plays in ensuring energy security worldwide.
However, the chart also reveals that Iran holds a significant share of crude oil reserves, accounting for approximately 24% of the total reserves in the Middle East. This statistic highlights the country's enormous potential in the global energy market, with the Iranian government investing heavily in the exploration and exploitation of its oil reserves to maximize its revenue generation capacity. Given the country's significant share of crude oil reserves, Iran remains a crucial player in the OPEC cartel, which controls global oil prices and production levels.
Moreover, the pie chart's statistics demonstrate the importance of the Middle East as a crucial energy hub in the global economy, with several countries contributing significantly to the region's oil reserves. These countries play a crucial role in ensuring global energy security, with their oil reserves being a critical component of the world's energy mix. Therefore, it is vital to monitor the evolving dynamics of the Middle Eastern oil market, including production levels, prices, and reserves, to ensure stable and secure global energy supplies.
In conclusion, the pie chart 3-1 presented in this thesis is a vital tool that provides valuable insights into the distribution of crude oil reserves among different OPEC countries in the Middle East in 2021. The chart's findings highlight the dominance of Saudi Arabia in the global oil market and the significant potential of Iran in the energy sector. Therefore, it is critical to monitor the evolving trends in the Middle Eastern oil market to ensure stable and secure energy supplies for the global economy.

Several articles on Iran's oil industry are examined, covering a wide range of topics, including the nationalization of the industry, the impact of oil income on economic growth, the effects of oil price shocks, government expenditures and revenues nexus, exchange rate fluctuations, and diversification strategies.

Economic growth and development have been critical concerns for many countries throughout the twentieth century. In the case of Iran, economic modernization and development were at the forefront of the country's political and social agenda.

Despite the diversity of the articles' topics, they share some commonalities, such as examining the role of macroeconomic factors in shaping Iran's economy and the impact of oil on economic growth and development. Additionally, some articles employ similar methodologies, such as dynamic panel models, cointegration techniques, and system dynamic models.

(Esfahani & Pesaran, 2009) provided a comprehensive overview of Iran's economic history and evolution in the context of global economic developments. The paper began by providing an overview of the Iranian economy's pre-twentieth-century history, highlighting the role of agriculture, handicrafts, and trade. Esfahani then proceeded to examine the country's economic performance in the twentieth century, identifying three distinct periods: the pre-oil period (1900-1950), the oil boom period (1950-1977), and the post-revolution period (1979-present).

Esfahani argued that the pre-oil period was marked by slow economic growth and a lack of modernization, which made the country vulnerable to foreign influence and domination. However, the discovery of oil in the 1950s brought significant economic growth and development to the country, leading to an era of modernization and industrialization. The author noted that during this period, Iran's economic growth rate was among the highest in the world, and the country emerged as a critical player in the global oil market.

However, the author argued that the country's dependence on oil revenue also made it vulnerable to external shocks, as evidenced by the 1970s oil price shock and the subsequent economic crisis. The author also discussed the social and political consequences of the oil boom period, including income inequality and political repression.

The paper also examined the economic developments in Iran since the 1979 revolution. The author argued that the revolutionary government redistributing wealth and resources resulted in significant social welfare, education, and health progress. However, the author also noted that structural problems, including a lack of diversification, poor governance, and corruption, plagued the country's economy.

Overall, Esfahani's paper provided an insightful and comprehensive overview of the Iranian economy's history and evolution in the context of global economic developments. The author's arguments were supported by a wealth of historical evidence, making the paper valuable to the scholarship. Esfahani's work highlighted the importance of understanding the historical context of the Iranian economy and its role in shaping the country's political and economic destiny. The paper also underscored the need for policies that promoted economic diversification, improved governance, and reduced dependence on oil revenues to achieve sustainable economic development in Iran.

(Ardakani, 1996) explored the impact of oil exports on Iran's economic development from 1960-1992. The author argued that the Iranian economy heavily relied on oil exports as the primary source of income and that this dependence hindered the development of other sectors, leading to economic instability and vulnerability to external shocks.

Ardakani provided a detailed analysis of the Iranian oil industry and its relationship with the government, emphasizing the importance of government policies in managing oil revenues and promoting economic growth. The author also examined the impact of the

Islamic Revolution in 1979 and the Iran-Iraq war on the oil industry and the broader economy, highlighting the devastating effects on infrastructure and production capacity. The dissertation presented statistical evidence and empirical analysis to support the author's arguments, including regression models that explored the relationship between oil exports and economic growth. Ardakani found that while oil exports positively impacted economic growth in the short term, the dependence on oil revenue hindered long-term development and contributed to economic instability.

The author concluded by discussing Iran's challenges in diversifying its economy and reducing its dependence on oil exports, suggesting policy recommendations to promote economic development in non-oil sectors. Overall, Ardakani's dissertation contributed to the scholarship on the Iranian economy and the role of oil exports in its development. The author's arguments were supported by thorough research and statistical analysis, making the dissertation an essential resource for scholars and policymakers interested in the Iranian economy.

(Farzanegan & Markwardt, 2009) examined the impact of oil price shocks on the Iranian economy from 1959 to 2005. The author used an error correction model to analyse oil price shocks' short and long-run effects on various macroeconomic variables such as GDP, inflation, and unemployment.

The paper found that oil price shocks significantly impacted the Iranian economy, with the most considerable effect observed in the short run. The author noted that the Iranian economy was heavily dependent on oil exports and, as such, was vulnerable to fluctuations in global oil prices.

The study results indicated that an increase in oil prices positively impacted Iran's GDP, while inflation and unemployment increased in the short run. In the long run, however, oil price shocks had a negative effect on Iran's economic growth, with inflation and unemployment continuing to rise.

Moreover, the paper highlighted that the Iranian government's policies, such as subsidies and price controls, exacerbated the impact of oil price shocks on the economy. The author argued that to reduce the negative impact of oil price shocks on the economy, the Iranian government should reduce its reliance on oil exports, diversify the economy, and implement structural reforms to improve productivity.

Overall, the paper provided valuable insights into the impact of oil price shocks on the Iranian economy and highlighted the need for policy measures to reduce the economy's dependence on oil exports. The author's use of a sophisticated econometric model strengthened the study's findings and made it a significant contribution to the literature.

(Emami & Adibpour, 2012) investigated the impact of oil income shocks on Iran's economic growth from 1960 to 2009. The author used a structural vector autoregression (SVAR) model to analyse the dynamic relationship between oil income, GDP growth, and other macroeconomic variables such as inflation, investment, and exports. The paper found that oil income shocks positively and significantly impacted Iran's economic growth, but the effect was temporary and faded away after a few years. The paper also revealed that oil income shocks harmed investment, which may offset some positive effects on economic growth. Furthermore, the paper found that the response of the Iranian economy to oil income shocks varied depending on the source of the shock. Shocks caused by changes in global oil prices had a more substantial impact on Iran's economy than shocks caused by changes in the country's oil production levels.

Overall, Emami's paper provided valuable insights into the complex relationship between oil income shocks and economic growth in Iran. The paper highlighted the short-term benefits of oil income on economic growth and underscored the risks and challenges posed by dependence on a single commodity. The author's use of the SVAR model provided a robust methodology for analysing the dynamic relationship between oil income and economic growth. The findings had significant implications for policymakers in Iran and other oil-exporting countries.

(Bahmani-Oskooee & Kandil, 2007) examined the relationship between exchange rate fluctuations and output in Iran's oil-producing economy. The author argued that fluctuations in the exchange rate could significantly impact the country's economic performance, mainly due to its reliance on oil exports. The paper used time-series data and the autoregressive distributed lag (ARDL) approach to investigate the short- and long-run effects of exchange rate fluctuations on output in Iran. The results suggested that exchange rate depreciations had a negative impact on output in the short run but a positive impact in the long run. The paper also examined the impact of exchange rate volatility on Iran's output, finding that volatility had a negative impact on output in both the short and long run. Bahmani-Oskooee argued that exchange rate volatility could lead to uncertainty and hinder economic investment, negatively impacting economic performance.

The paper provided valuable insights into the relationship between exchange rate fluctuations and output in Iran's oil-producing economy. The author's use of time-series data and the ARDL approach enhanced the robustness of the findings. At the same time, discussing the potential mechanisms driving the observed effects enriched the paper's contribution to the scholarship. The paper suggested that policy efforts to stabilize exchange rates may benefit Iran's economic growth and stability in the long run.

(Dizaji, 2012) analysed the impact of oil price shocks on Iran's government expenditures and revenues nexus. The author began by providing an overview of Iran's oil-dependent economy and its history of oil price shocks. The paper then used a vector autoregressive (VAR) model to investigate the relationship between oil prices, government expenditures, and government revenues in Iran from 1975 to 2010.

Dizaji found that oil price shocks significantly impacted government expenditures and revenues in Iran. The author noted that an increase in oil prices led to increased government revenues but also caused an increase in government expenditures. This was particularly true for current government expenditures, which were more sensitive to changes in oil prices than capital expenditures. Additionally, the author found that the impact of oil price shocks on government expenditures and revenues was asymmetric, with adverse shocks having a more significant impact than positive shocks.

The study also examined the effect of oil price shocks on the fiscal balance, which is the difference between government revenues and expenditures. The author found that oil price shocks hurt the fiscal balance, particularly in the short run. The author noted that this effect was more pronounced for negative shocks, which resulted in a more significant decrease in the fiscal balance than positive shocks.

Dizaji's study provided valuable insights into the impact of oil price shocks on the government expenditures and revenues nexus in Iran. The author's use of a VAR model allowed for a detailed analysis of the dynamic relationship between oil prices, government expenditures, and government revenues. The findings suggested that oil price shocks had significant implications for fiscal policy in Iran, highlighting the importance of managing oil revenues effectively to mitigate the adverse effects of oil price volatility. The study contributed to the literature on the relationship between oil prices and government fiscal policy in oil-exporting countries.

(Mehrara & Sujoudi, 2015) investigated the relationship between money, government spending, and inflation in the Iranian economy. The author employed time series data from 1974 to 2013 to examine these variables' long-run and short-run relationships. Mehrara used cointegration and error correction models to explore the dynamic relationships between the variables of interest. The results suggest a significant long-run relationship between money supply, government spending, and inflation in Iran. The author found that increased government spending increases the money supply, leading to higher inflation rates. The paper also indicated that the government's monetary policy had played a vital role in controlling inflation in Iran.

Moreover, Mehrara found that the government's fiscal policy, measured by government spending, has a positive and significant effect on inflation in the short run. However, this effect dissipates in the long run, suggesting that the Iranian government's fiscal policy has a limited impact on inflation in the long term. Overall, Mehrara's paper provided valuable insights into the relationships between money supply, government spending, and inflation in the Iranian economy. The author used time series data and statistical methods robustly analyse these relationships. The paper's findings have significant implications for policymakers in Iran and highlight the need for a coordinated monetary and fiscal policy to control inflation and promote economic stability.

(Dudlák, 2018) examined the policy challenges facing Iran's oil and gas sectors in the aftermath of the lifting of international sanctions. The author argued that lifting sanctions presents opportunities and challenges for Iran's energy sector, which has long been a crucial component of the country's economy.

Dudlak began by providing a historical overview of the sanctions imposed on Iran and their impact on the country's oil and gas sectors. The author noted that the sanctions significantly impacted Iran's energy exports and investment in the sector, leading to a decline in production and revenues. Dudlak then explores the potential policy responses to lifting sanctions, including strategies for attracting foreign investment, promoting domestic innovation, and reducing the sector's environmental impact.

The author argued that while lifting sanctions has created new opportunities for Iran's energy sector, the sector still needs to overcome significant challenges, including outdated infrastructure, insufficient investment, and an overreliance on oil exports. Dudlak suggested that Iran needs to adopt policies that encourage investment in alternative energy sources, improve the efficiency of its oil and gas production, and diversify its export markets.

Dudlak's paper provides a valuable analysis of the policy challenges facing Iran's energy sector in the aftermath of lifting international sanctions. The author's arguments are well-supported by a wealth of data and historical evidence, making the paper valuable to the scholarship. Dudlak's work highlights the importance of understanding the political and economic dynamics that shape Iran's energy sector and the challenges the country faces in transitioning to a new political economy in this critical sector.

(Eltejaei, 2018) examined the relationship between oil revenue, government spending, and economic growth for a panel of selected oil-exporting countries, including Iran. The author used a dynamic panel data model to investigate the impact of oil revenue on government spending and economic growth while controlling for other factors that may affect economic growth, such as human capital, physical capital, and inflation.

Eltejaei found that oil revenue has a positive and statistically significant effect on government spending in oil-exporting countries, including Iran. However, the author also found that government spending harms economic growth, suggesting that the government's ability to allocate resources effectively may be limited.

Furthermore, the author found that the relationship between oil revenue and economic growth is nonlinear and depends on the level of government spending. Specifically, oil revenue positively affects economic growth when government spending is low. However, when government spending is high, the effect of oil revenue on economic growth is negative.

The findings of Eltejaei's paper have important implications for policymakers in oil-exporting countries like Iran. The author suggested governments should use oil revenue to invest in productive assets, such as human and physical capital, to promote sustainable economic growth rather than relying on government spending alone. The author also recommended that policymakers focus on reducing inefficiencies in government spending and improving the quality of institutions to promote economic growth.

Overall, Eltejaei's paper provides valuable insights into the complex relationship between oil revenue, government spending, and economic growth in oil-exporting countries. The author's use of a dynamic panel data model and the inclusion of a range of control variables add to the rigour of the analysis and enhance the credibility of the findings. The paper highlights the importance of prudent fiscal policy and effective resource allocation in promoting sustainable economic growth in oil-exporting countries.

(Kiani & Ali Pourfakhraei, 2010) presented a system dynamics model for production and consumption policy in Iran's oil and gas sector. The author argued that the policy-making process in the energy sector requires a comprehensive understanding of the interrelationships among various factors, such as energy demand, production, investment, and government policies. Kiani used a system dynamics approach to model the complex interactions between these factors and their impact on Iran's energy sector.

The paper begins with an overview of Iran's energy sector, highlighting its significance for its economy and society. The author then explained the concept of system dynamics and its relevance to the energy sector. Kiani argued that the dynamic nature of the energy sector requires a systems approach to capture the interdependencies among various factors and their impact on the sector's performance.

The author presented a model that captures the interactions between energy demand, production, and investment in the oil and gas sector. The model also incorporates the impact of government policies, such as subsidies, tax incentives, and investment in infrastructure. Kiani used data from Iran's oil and gas sector to calibrate the model and test its validity.

The model results suggest that the Iranian government's policies significantly impact the sector's performance, particularly in investment and production. The author noted that the government's subsidies and tax incentives for energy production could lead to overproduction and inefficiencies in the sector. The model also suggests that the government's investment in infrastructure can positively impact the sector's performance by reducing transportation costs and increasing efficiency.

Overall, Kiani's paper contributes to the literature on Iran's energy sector by presenting a comprehensive system dynamics model that captures the complex interactions among various factors. The author's approach can help policymakers and stakeholders to develop effective policies and strategies for the sector's sustainable development. The paper's emphasis on the importance of government policies and investment in infrastructure highlights the need for a comprehensive and coordinated approach to energy policy in Iran.

(Pahlavani, 2005). The relationship between trade and economic growth in Iran was examined using a new cointegration technique that accounts for structural breaks. The author argued that international trade had played a critical role in Iran's economic growth and development, particularly in the post-revolutionary period.

Pahlavani provided a detailed analysis of Iran's trade and economic growth trends from 1960 to 2003. The author employed various statistical methods, including unit root tests, cointegration analysis, and Granger causality tests, to examine the relationship between trade and economic growth in Iran. The author also explored the impact of structural breaks, such as the Iranian Revolution of 1979 and the Iran-Iraq War of 1980-1988, on the relationship between trade and economic growth.

The dissertation's findings suggest a long-run relationship between trade and economic growth in Iran, with trade positively affecting economic growth. The author also found that the relationship between trade and economic growth is unaffected by structural breaks, indicating that international trade has been a critical factor in Iran's economic development, even during the political and economic upheaval.

Pahlavani's work makes a valuable contribution to the scholarship on the relationship between trade and economic growth in Iran. The author's use of a new cointegration technique that accounts for structural breaks provides a more accurate picture of the relationship between trade and economic growth in Iran. Moreover, the dissertation's findings highlight the importance of international trade for Iran's economic growth and development, even in the face of significant political and economic challenges. Overall, Pahlavani's dissertation is a valuable resource for researchers and policymakers interested in understanding the role of trade in Iran's economic development.

(Shafaeddin, 2001) provided an insightful analysis of the challenges faced by an oil-exporting country like Iran in achieving sustainable economic development. The author argued that the oil sector's dominance had hindered the development of other sectors, such as manufacturing and agriculture, leading to a lack of diversification and over-dependence on oil exports.

The paper highlights the importance of economic diversification for sustainable development and argues that a comprehensive long-term strategy is necessary to achieve this goal. The author suggested that the government should take a more active role in promoting industrialization and creating employment opportunities in non-oil sectors. Shafaeddin also emphasized the need for a supportive institutional environment and a comprehensive education system to build human capital and increase productivity.

The paper provides a detailed analysis of the challenges faced by Iran in achieving economic diversification, including institutional weaknesses, a lack of infrastructure, and insufficient investment in research and development. The author also discusses the impact of global economic trends, such as globalization and trade liberalization, on Iran's economy and the need to adapt to these changes to remain competitive.

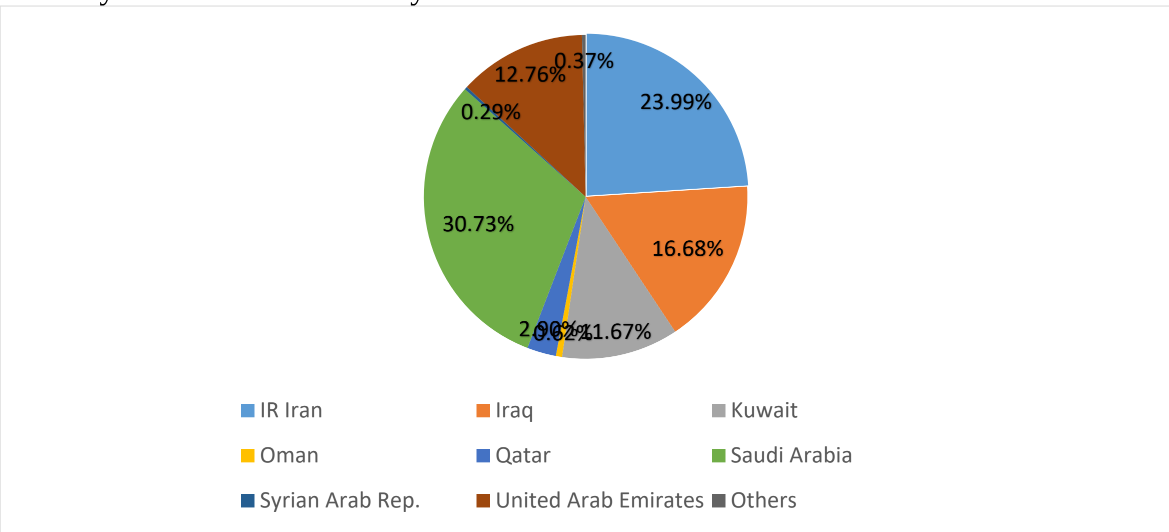
Shafaeddin's paper offers a valuable contribution to the scholarship on economic development in oil-exporting countries and provides a practical framework for policymakers and scholars interested in promoting sustainable development. The author's arguments are supported by empirical evidence, making the paper a valuable resource for those interested in understanding Iran's economy's challenges and opportunities. Overall, the paper is a thoughtful and insightful analysis of the complexities of achieving economic diversification in an oil-exporting country and provides a valuable framework for developing a long-term strategy for sustainable development.

(Mahmoodi, 2017) examined the effects of falling oil prices on the Iranian economy. He argued that the decline in oil prices had significantly impacted the country's economic performance, with negative consequences for growth, employment, and government revenues.

Mahmoodi provided a detailed analysis of the Iranian economy, including its heavy dependence on oil exports and its challenges in diversifying it. The author used various statistical methods, including regression analysis and an input-output model, to analyse the effects of falling oil prices on various economic indicators.

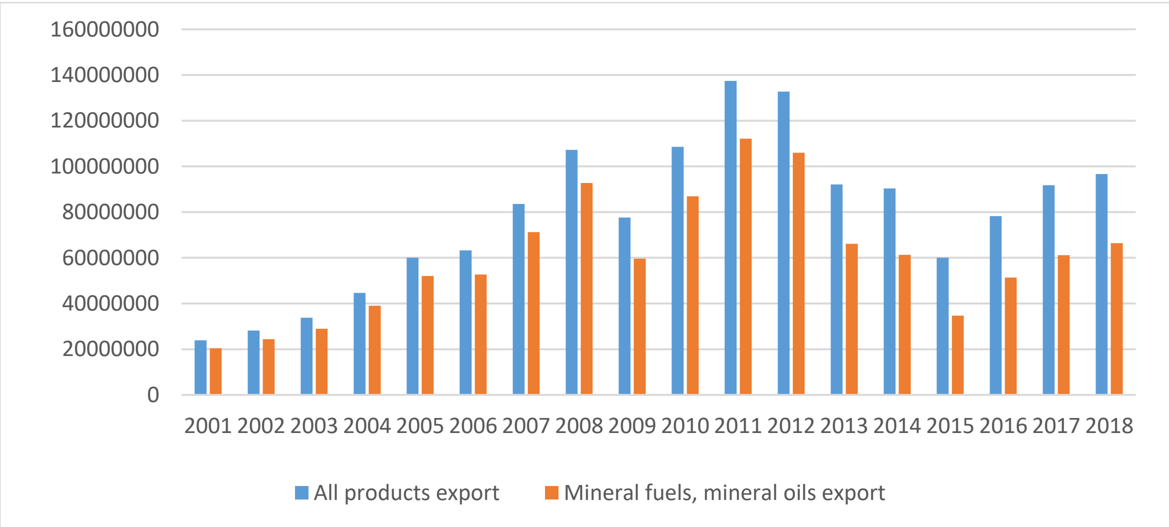
The paper highlights the negative impact of falling oil prices on Iran's economy, particularly government revenues, which rely heavily on oil income. Mahmoodi notes that the decline in oil prices has led to a decline in export earnings and a reduction in government spending, leading to job losses and an economic slowdown. The author also examined the impact of falling oil prices on different sectors of the economy, including agriculture, manufacturing, and services, and notes that the decline in oil prices has had a significant negative impact on these sectors as well.

Overall, Mahmoodi's paper provides a comprehensive and insightful analysis of the impact of falling oil prices on the Iranian economy. A wealth of statistical evidence supports the author's arguments, making the paper valuable to the scholarship. The paper highlights Iran's challenges in diversifying its economy and reducing its dependence on oil exports. Furthermore, the paper underscores the need for policies that promote economic diversification and reduce reliance on oil exports to mitigate the adverse effects of oil price volatility on the Iranian economy.



Source OPEC data (OPEC, n.d.)

Figure 3-1 crude oil reserves by countries in middle east in 2021



Source tradingeconomics.com (tradingeconomics, n.d.)

Figure 3-2 total export value vs mineral fuels

Figure 3-2 enables to compare Iran's total export value against the export value of mineral fuels and mineral oils (primarily consisting of oil and gas products) for the years 2001-2018. Between 2001 and 2008, both total exports and mineral fuels exports experienced a significant increase. Total exports grew from $23.904 billion in 2001 to $107.236 billion in 2008, while mineral fuels exports increased from $20.368 billion in 2001 to $92.744 billion in 2008. During this period, the proportion of mineral fuels exports to total exports remained relatively stable, ranging between 85% and 87%. This demonstrates the significant contribution of mineral fuels, particularly oil, to Iran's export earnings during this time.

In 2009, a sharp decline was observed in both total exports and mineral fuels exports, with total exports falling to $77.575 billion and mineral fuels exports dropping to $59.613 billion. The proportion of mineral fuels exports to total exports increased to approximately 77%, highlighting the vulnerability of Iran's export sector to fluctuations in global oil prices and demand.

From 2010 to 2012, there was a recovery in export values, with total exports peaking at $137.421 billion in 2011 and mineral fuels exports reaching $112.101 billion the same year. However, 2012 saw a slight decrease in both categories, with total exports at $132.713 billion and mineral fuels exports at $105.996 billion.

Between 2013 and 2015, a downward trend was observed, with total exports falling to $60.041 billion and mineral fuels exports dropping to $34.705 billion in 2015. During this period, the proportion of mineral fuels exports to total exports also declined, reaching approximately 58% in 2015. This decrease can be attributed to the impact of international sanctions on Iran's oil exports and overall economy.

From 2016 to 2018, a recovery in export values took place. Total exports increased to $96.618 billion in 2018, while mineral fuels exports reached $66.367 billion the same year. The proportion of mineral fuels exports to total exports also increased, settling at around 69% in 2018.

In conclusion, the comparison of total export values and mineral fuels export values for Iran between 2001 and 2018 reveals the significant role of mineral fuels, particularly oil, in Iran's export sector. While there were periods of growth and decline, the overall trend indicates that mineral fuels constitute a substantial portion of Iran's export earnings, with the proportion ranging from 58% to 87% during the analysed years. This underscores the importance of the oil sector for Iran's economy and the need to focus on diversifying its export portfolio to mitigate vulnerability to external shocks and fluctuations in global oil markets.

3.3 Iran's Petroleum Products Industry

The country's petroleum products sector has been a significant contributor to its economy, generating substantial revenue through exports and meeting the domestic demand for fuel and energy. However, the industry has faced several challenges, including concerns about meeting environmental standards, fluctuating oil prices, and the impact of international sanctions. Refining capacity is the amount of crude oil that a refinery can process per day, while refining throughput is the actual amount of crude oil processed by a refinery in a day. The Figure 3-3 shows Iran's refining capacity, refining throughput, main petroleum products demand, and petroleum products output from 1980 to 2021. The main petroleum products include gasoline, diesel, fuel oil, and kerosene.

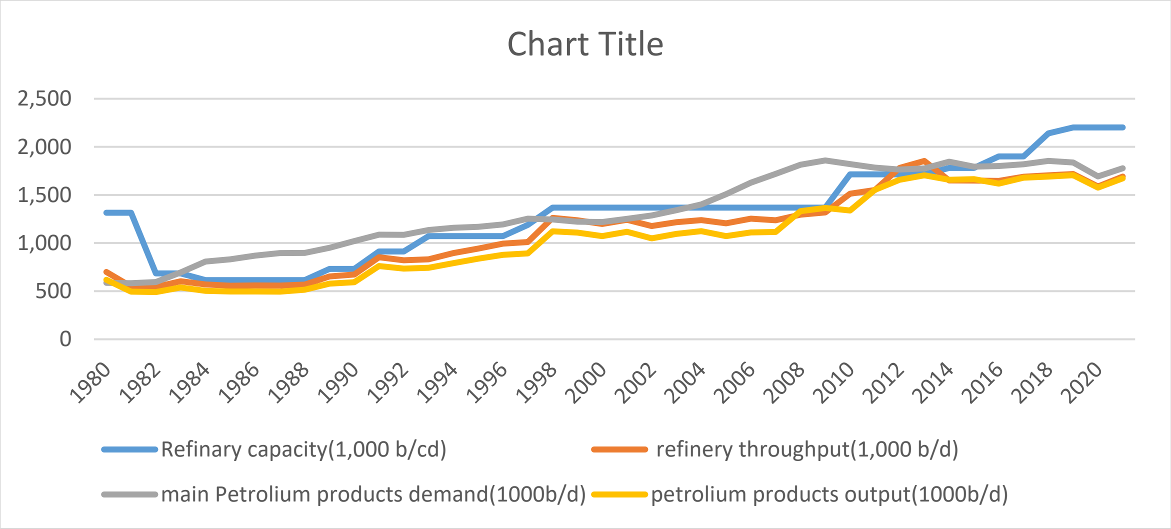


Figure 3-3 Iran's refinary capacity and demand

From the Figure 3-3, it can be observed that Iran's refining capacity and throughput have increased significantly over the years. However, there is a slight dip in refining throughput in 2020. The increase in refining capacity and throughput can be attributed to Iran's efforts to become more self-sufficient in meeting its domestic demand for petroleum products. This figure also shows that the demand for main petroleum products in Iran has grown steadily over the years, with a peak in 2018 at 1,854,000 b/d. The petroleum products output has also increased in tandem with the demand, except for some minor fluctuations. However, the slight decrease in petroleum products output in 2020 may be attributed to the COVID-19 pandemic, which led to a drop in demand for petroleum products globally. Overall, the above-mentioned figure suggests that Iran's refining industry has made significant progress in meeting the domestic demand for petroleum products. However, the industry still has room for improvement in terms of operational efficiency and meeting environmental standards. Therefore, Iran's policymakers need to consider investing in technology and infrastructure to improve the sector's operational efficiency while also ensuring that the industry meets the environmental standards set by international bodies. Iran's petroleum products industry has faced criticism for failing to meet international environmental standards. According to a report by the United Nations Environment Programme (UNEP) in 2017, the quality of gasoline and diesel produced in Iran did not meet international environmental standards. The report also highlighted that the sulfur content in gasoline and diesel produced in Iran was higher than the international standards, which could result in significant air pollution and adverse health effects (UNEP, 2017). Furthermore, (Sattari & Avami, 2008) provided a comprehensive analysis of the structural, energy, and environmental aspects of Iranian oil refineries. It gave a detailed overview of the various types of equipment used in refineries, the different types of crude oil that were processed, and the energy sources used in Iranian refineries. The article also highlighted the environmental impact of oil refineries and described the measures taken to mitigate these impacts. The insights provided by the authors could have been of interest to policymakers, industry practitioners, and researchers in the field.

(Hosseini & Stefaniec, 2019)article examined the efficiency of Iran's petroleum refining industry, taking into account the presence of unprofitable outputs. The authors used a dynamic two-stage slacks-based measure to assess the efficiency of the industry, providing a detailed analysis of the data and presenting their findings in a clear and concise manner.

The article provided valuable insights into the factors that contributed to the inefficiency of the Iranian refineries, such as the high level of energy consumption and the low level of utilization of resources. The authors also discussed the impact of unprofitable outputs, such as environmental pollution, on the efficiency of the refineries. The insights provided by the authors could have been of interest to policymakers, industry practitioners, and researchers in the field.

In conclusion, while Iran has taken some steps to improve the quality of its petroleum products, there are still concerns about the industry's compliance with environmental standards. Therefore, Iran's policymakers need to prioritize investing in advanced technologies and infrastructure to improve the sector's environmental performance while meeting the country's growing demand for petroleum products.

3.4 Dutch disease

The Dutch disease phenomenon, which refers to the adverse economic effects of a natural resource boom, has been studied extensively in the literature on natural resource abundance and economic development. (Brinčíková, 2016) overview of the Dutch disease highlights that a surge in natural resource exports can lead to an appreciation of a country's currency, making other sectors of the economy less competitive and resulting in a decline in their exports and production.

Farzanegan investigated the impact of oil price shocks on the Iranian economy, which heavily relies on oil exports. The study found that oil price shocks significantly negatively impacted Iran's economy, leading to a decline in real GDP, inflation, and investment. This study suggests that Iran's heavy dependence on oil exports has made its economy vulnerable to external shocks, including fluctuations in oil prices, which can lead to Dutch disease.

(Esfahani, 2014) developed an empirical growth model for major oil exporters, including Iran, to examine the impact of natural resource abundance on economic growth. The study found that natural resource abundance had a negative impact on economic growth, particularly in countries with lower levels of human capital and weak institutions. This finding suggests that Dutch disease can hinder economic growth in resource-rich countries.

Emami and Adibpour explored the relationship between oil income shocks and economic growth in Iran. The study found that oil income shocks positively impacted Iran's economic growth in the short run but negatively in the long run. The study suggests that the Dutch disease phenomenon may have contributed to the negative impact of oil income shocks on economic growth in the long run.

Overall, the literature reviewed highlights the harmful effects of Dutch disease on resource-rich economies, such as Iran. The studies suggest that the adverse effects of natural resource abundance can hinder economic growth, especially in countries with weak institutions and low levels of human capital. Therefore, policies should be implemented to mitigate the Dutch disease's negative impact and promote economic diversification in these countries.

3.5 Sanctions

Over the years, the US and EU have implemented some sanctions against Iran by freezing Iranian capital abroad, banning the import of goods and services or investments in oil and gas, closing the financial market to the Iranians, and blocking all the assets of the Central

Bank and all the institutions connected to the regime. In this study, only sanctions related to crude oil are considered.

In 2012, the United Nations (UN) council adopted measures against Iran due to concerns over its nuclear program. At the same time, the European Union (EU) imposed additional sanctions on Iran, including trade in dual-use goods, equipment, and technologies that can be used in petrochemicals. The sanctions also prohibited Iran's crude oil, petroleum, and petrochemical products and investments in the petrochemical industry. The delivery of newly printed banknotes and coinage to Iran's Central Bank was also prohibited, as well as trade in gold, precious metals, and diamonds with the Government of Iran (legal content, n.d.). The effects of sanctions significantly intensified in 2012, as a coalition led by the US imposed global financial sanctions on Iran due to its nuclear program. These measures restricted the Iranian central bank's access to the payment system for settling transactions in US dollars, and the European Union banned imports of Iranian oil while imposing stricter sanctions on the banking, trade, and energy sectors. Consequently, Iran's oil exports were reduced, and the country was excluded from the global financial system, causing the Iranian rial to plummet to a historic low (Kandil & Mirzaie, 2021).

However, during the P5+1 summit on November 24, 2013, the United States and its partners agreed with Iran, outlined in the Joint Plan of Action (JPOA), to halt Iran's nuclear development and reverse some steps. Under the agreement, Iran would receive limited, targeted, and reversible sanctions relief if it agreed to place meaningful limits on its nuclear program (US Department of State, 2013). In January 2014, the US Department of State and Treasury implemented sanctions relief relating to specific activities and associated services that would occur exclusively between January 20, 2014, and July 20, 2014, as part of the US Government's commitments under the JPOA (US Treasury Archive).

According to (Ahmadi, 2018) and (Devarajan & Mottaghi, 2015), the Iranian economy experienced a positive impact from the lifting of sanctions, including increased oil production and exports, expanded trade, and overall economic growth. (Ianchovichina, Devarajan, & Lakatos, 2016) provides a quantification of the welfare gains for Iran resulting from the relief of sanctions, with the most optimistic scenario projecting a 6.5% increase in per capita welfare. However, (Madani, 2021) argues that the sanctions had some unintended environmental consequences, as they limited Iran's access to technology and led to an increase in the natural resource-intensity of the economy. Despite the unintended consequences, the papers suggest that the JPOA relief of sanctions had a significant impact on Iran's economy.

In July 2015, the P5+1, the European Union, and Iran agreed on a Joint Comprehensive Plan of Action (JCPOA) to ensure Iran's nuclear program is exclusively peaceful. The JCPOA led to the lifting of many economic sanctions imposed on Iran, particularly concerning its oil industry.

the influence of the JCPOA on Iran's economy is not straightforward. While (Ahmadi, 2018) found that the JCPOA could have a positive impact on Iran's petroleum production, exports, and economy, he also notes that international sanctions and political uncertainty have created challenges for Iran's economy. (Dadpay, 2019) found that the JCPOA had a modest impact on Iran's aviation industry, with international airlines being more successful than their Iranian counterparts in expanding their services to Iran. On the other hand, (Khosravi & Jafari, 2020) found that the fluctuations in economic growth rate related to the JCPOA led to political instability in Iran through deepening and intensification of expectations gap. Moreover, (Dadpay & Tabrizy, 2021) found that the JCPOA had a significant positive effect on Iran's non-oil exports, particularly in industries with relatively low shares in Iran's non-oil exports. The papers suggest that the impact of the JCPOA on Iran's economy is intricate and multifaceted, with both positive and negative effects.

In 2016, following the implementation of the Joint Comprehensive Plan of Action (JCPOA), the International Atomic Energy Agency (IAEA) confirmed that Iran had complied with its key nuclear-related measures described in the agreement. As a result, many economic sanctions imposed on Iran were suspended, and the European Union lifted the nuclear-related secondary sanctions applicable to non-US persons and entities. However, primary sanctions, which apply to US persons and entities, remained in force (U.S. DEPARTMENT OF THE TREASURY, 2016).

The lifting of the sanctions had a positive impact on Iran's economy (Khamenei & Shahidinia, 2020)Found that the lifting of the sanctions led to a significant increase in Iran's oil exports and an increase in its GDP. The research suggests that lifting the sanctions helped increase foreign investment in Iran, which led to the creation of new jobs and increased economic growth.

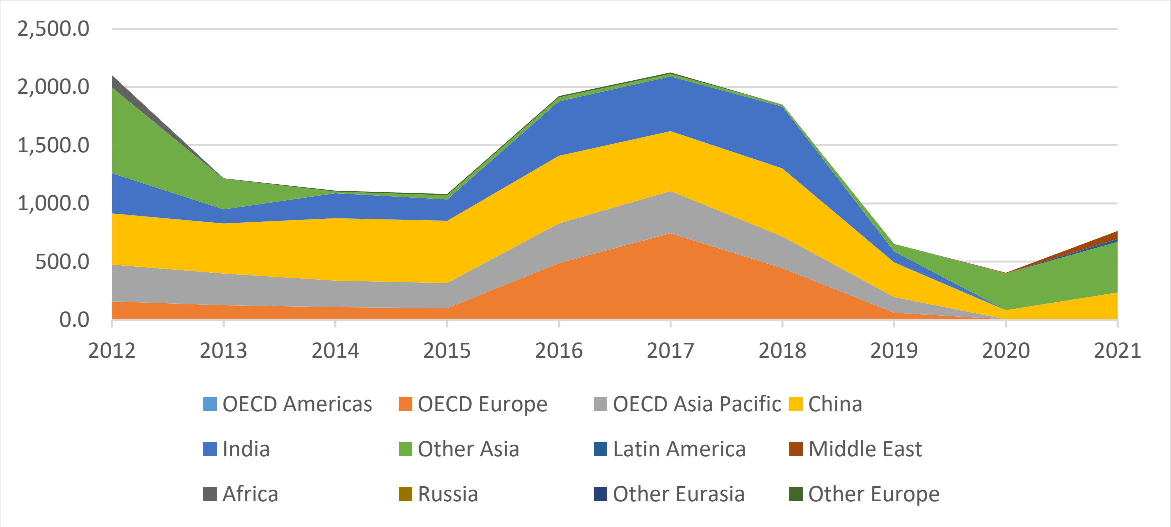
However, the impact of the sanctions on Iran's economy was still felt in many areas. Sanctions contributed to a decline in Iran's oil production, significantly impacting the country's economy (Zhukov & Reznikova, 2020). Additionally, the sanctions limited Iran's access to international financial markets, which made it difficult for the country to finance its development projects (Khamenei & Shahidinia, 2020) .Despite the positive outcomes of lifting the sanctions, the impact of the sanctions on Iran's economy highlights the need for continued study and exploration of potential solutions to the country's challenges.

The US president announced the decision to cease US participation in the JCPOA.

As of May 8, 2018, the President announced that he would cease participating in the Joint Comprehensive Plan of Action (JCPOA) and reimpose US nuclear-related sanctions lifted to facilitate the relief of JCPOA sanctions after a wind-down period. This announcement was accompanied by a National Security Presidential Memorandum (NSPM) in which the President directed the Secretary of State and Treasury to prepare for the reimposition of US sanctions lifted or waived in connection with the JCPOA expeditiously as possible within 180 days of the NSPM becoming effective(US treasury archive).

(Feghe Majidi & Zarouni, 2020) found that sanctions have impacted much of Iran's economy, including financial restrictions, decreased investment, rising unemployment, and inflation, leading to a slowdown. (Farzanegan M. , 2013) found that sanctions have transmitted their effects mainly through the foreign exchange market and have contributed to an increase in the size of Iran's informal economy. (Laudati & Pesaran, 2021) quantified the effects of sanctions in Iran on exchange rates, inflation, output growth, employment, labour force participation, and secondary and high school education. Their analysis included reduced-form equations and structural vector autoregressive (SVAR) models, which identified the direct and indirect effects of sanctions on the price of the Iranian rial versus the US dollar. They concluded that sanctions significantly affect exchange rates, inflation, and output growth, with the Iranian rial overreacting to sanctions followed by a rise in inflation and a fall in output.

(Hassanzadeh, 2015) suggests a political debate in Iran about allocating gas to domestic or export markets, which has failed to meet commitments to either market. (Zhukov, 2020) suggests that, due to sanctions, the technological level of the Iranian oil sector remains extremely low. (Payam & Taheri, 2018) suggests that, while dependency on oil challenges countries' security in various areas, the new alternative energy provides sustainable development and security for their consumers. These findings suggest that the significant challenges facing Iran's oil industry are political, economic, and technological. Sanctions have had a strong negative impact on the dynamics of Iranian oil production. More likely, a significant portion of commercially competitive Iranian oil will remain in the ground (Zhukov, 2020).



Source OPEC data

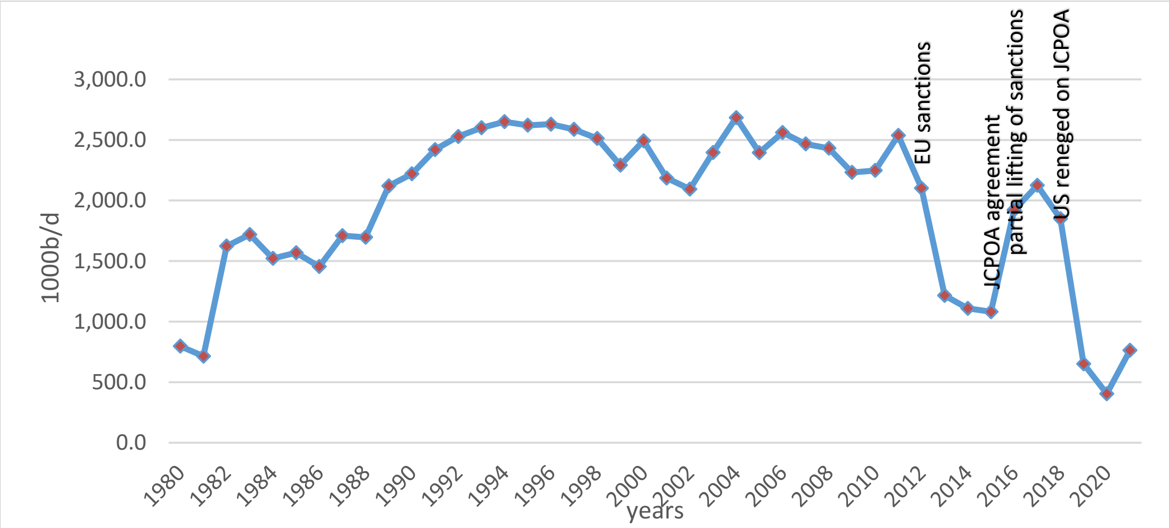
Figure 3-4 Oil export destination from Iran

The Figure 3-4 highlights the significant role of Asia in Iran's oil exports, with China and India being the top importers of Iranian crude oil. This indicates that the Asian market remains a crucial source of revenue for Iran's oil industry. However, there has been a significant shift in the export destinations of Iran's oil over the years, with a decrease in exports to Europe and Asia Pacific.

One factor that could have contributed to this shift is the impact of US sanctions on Iran's oil exports. The US has been pressuring other countries to reduce or completely stop importing oil from Iran, which has led to a decrease in Iran's oil exports to Europe and Asia Pacific. Additionally, the COVID-19 pandemic and the resulting decrease in global oil demand may have contributed to the decline in Iran's oil exports to these regions.

It is interesting to note that Iran has increased its oil exports to the United States in recent years, with a small but significant amount exported in 2021. This could be an attempt by Iran to diversify its export destinations and reduce its dependence on the Asian market.

Overall, the data highlights the challenges faced by Iran's oil industry in terms of export destinations, as well as the impact of external factors such as sanctions and global oil demand. Moving forward, Iran may need to explore new strategies to boost its oil exports and diversify its markets, while also pursuing alternative sources of revenue to reduce its dependence on oil.



Source OPEC data
Figure 3-5 Crude oil exports by Iran and the sanctions

Figure 3-5 highlights the significant impact of sanctions and international agreements on Iran's crude oil export. As shown, Iran's crude oil export reached its peak in 2004, with over 2500,000 barrels per day, but then remained steady at an average of 2400,000 barrels per day until 2012, when the EU imposed sanctions on Iran. These sanctions caused a drop of more than 50% in Iran's crude oil export.
However, in 2015, when the Joint Comprehensive Plan of Action (JCPOA) was signed between Iran and the P5+1 countries, which led to the partial lifting of sanctions, Iran's crude oil export started to increase again. Nevertheless, the situation changed again after the US withdrew from the JCPOA in 2018 and re-imposed sanctions on Iran. This resulted in a decline of more than 50% in Iran's crude oil export once again.
It is clear that Iran's crude oil export has been highly sensitive to international events, including sanctions and agreements. The fluctuation in the crude oil export can have significant impacts on Iran's economy, given the importance of crude oil exports to the country's revenue. The decline in crude oil export after the US withdrew from the JCPOA and re-imposed sanctions has led to a challenging economic situation for Iran. It has also highlighted the need for Iran to diversify its economy and reduce its dependence on oil exports.
Furthermore, the fluctuations in Iran's crude oil export demonstrate the importance of political stability and international cooperation for the economic development of countries. The Iranian government must focus on maintaining political stability and building strong diplomatic relationships with other countries to ensure a steady flow of crude oil exports and other economic benefits.

3.6 Overview of Iranian economic development

Iran's diverse economy relies heavily on its oil and gas reserves, with the oil sector being the most significant contributor to the country's GDP. However, Iran has been facing significant economic challenges in recent years, including the impact of international sanctions, low oil prices, and high inflation.

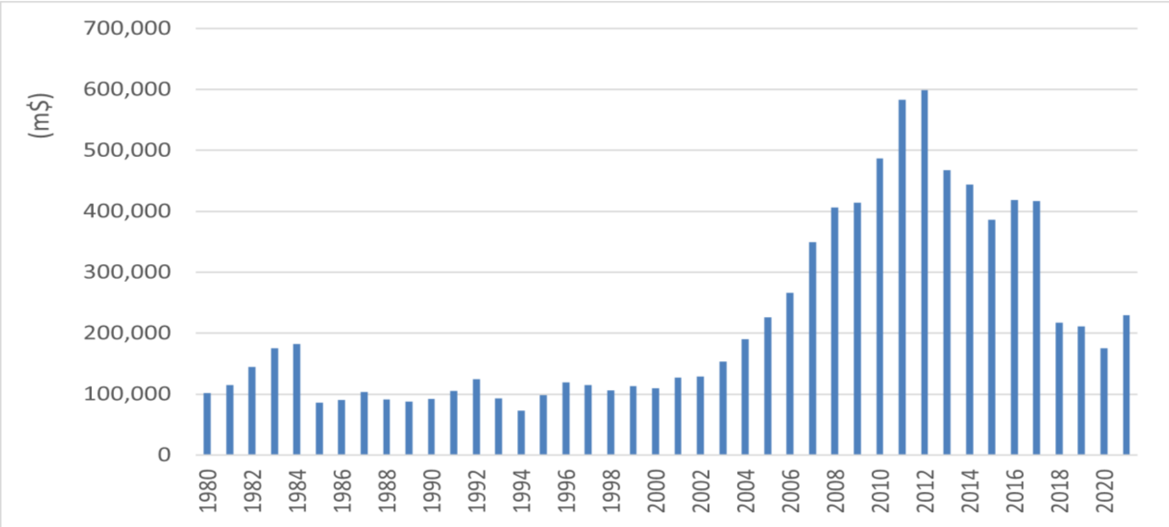
Despite these challenges, Iran has made significant efforts to develop its economy and diversify its sources of income beyond the oil and gas sectors. The government has implemented several economic reforms to improve the business environment, attract foreign investment, and promote non-oil exports.
Various factors, including political instability, economic sanctions, and fluctuations in oil prices, have shaped the country's economic development. However, the country's young and educated population, abundant natural resources, and strategic location make it a potentially attractive destination for foreign investors.
In recent years, Iran has focused on increasing its economic ties with neighbouring countries and developing non-oil exports, including agriculture, manufacturing, and tourism. The country has also invested in its infrastructure, including transportation and telecommunications, to attract foreign investors and enhance its competitiveness in the global economy.
Two critical indicators of Iran's economic development will be explored: GDP and external debt. Iran's GDP will be examined over time to assess how economic and political factors have impacted it. The external debt of Iran will also be considered, including the amount of debt owed to other countries and how it has been managed over time. By examining these two indicators, a better understanding of Iran's economic development and the challenges faced in recent years can be gained.

3.6.1 Gross domestic product

As a foundational step in conducting a comprehensive regression analysis of the Iranian national economy and its growth trajectory, it is crucial to delve into the various dimensions of Iranian economic development and to pinpoint the specific role that crude oil exports play in this context. A thorough understanding of these elements will enable us to ascertain whether oil exports have a significant impact on the overall growth of the nation's economy.
As illustrated in Figure 3-6, Iran's GDP in million US dollars from 1980 to 2021, allows us to discern distinct patterns and trends in the country's economic performance over four decades.

During the 1980s, Iran experienced a period of fluctuation, with GDP rising from $101,461 million in 1980 to $182,220 million in 1984, followed by a steep decline to $86,413 million in 1985. This drop can be largely attributed to the ongoing Iran-Iraq war, which severely impacted the nation's economy. The remaining years of the 1980s saw a slow recovery, with GDP figures hovering around $90,000 to $100,000 million.
The 1990s saw a generally positive trend, with GDP gradually increasing from $91,941 million in 1990 to $119,693 million in 1996. However, this growth was followed by a brief period of decline until 1999, when GDP began to rise again, reaching $113,237 million.
From 2000 to 2012, Iran experienced a period of significant economic expansion, with GDP more than quintupling from $109,592 million in 2000 to $598,853 million in 2012. This growth can be attributed to multiple factors, including rising oil prices and increased government spending on infrastructure projects.
However, from 2013 to 2015, Iran's GDP experienced a substantial downturn, falling from $467,415 million in 2013 to $385,874 million in 2015. This decline can be associated with the imposition of international sanctions on Iran, which negatively impacted its oil exports and overall economy.

From 2016 to 2017, there was a slight recovery, with GDP rising to $418,977 million in 2016 and $416,706 million in 2017. This can be partly attributed to the lifting of some sanctions under the Iran nuclear deal (JCPOA).
Unfortunately, GDP plummeted to $217,240 million in 2018 and continued to decline to $175,165 million in 2020. This can be linked to the re-imposition of US sanctions after the US withdrawal from the JCPOA in 2018, as well as the global economic slowdown due to the COVID-19 pandemic.
In 2021, Iran's GDP saw a partial recovery, reaching $230,014 million, although still far below the peak levels seen in the previous decade.
In conclusion, Iran's GDP has experienced periods of growth and decline over the past four decades, influenced by factors such as regional conflicts, fluctuations in oil prices, international sanctions, and global economic events.

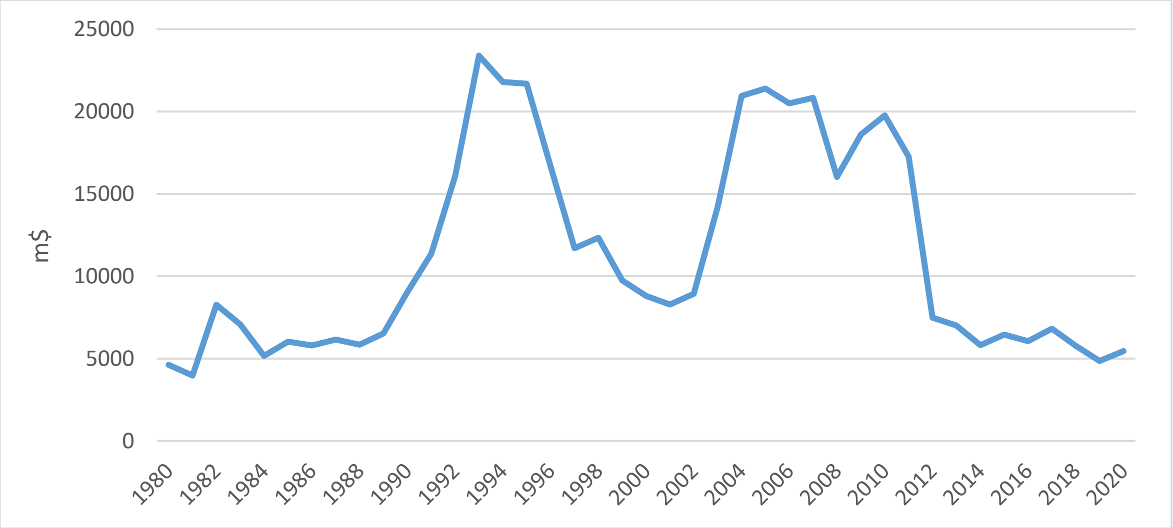


Source OPEC dataset
Figure 3-6 GDP at current market prices in Iran

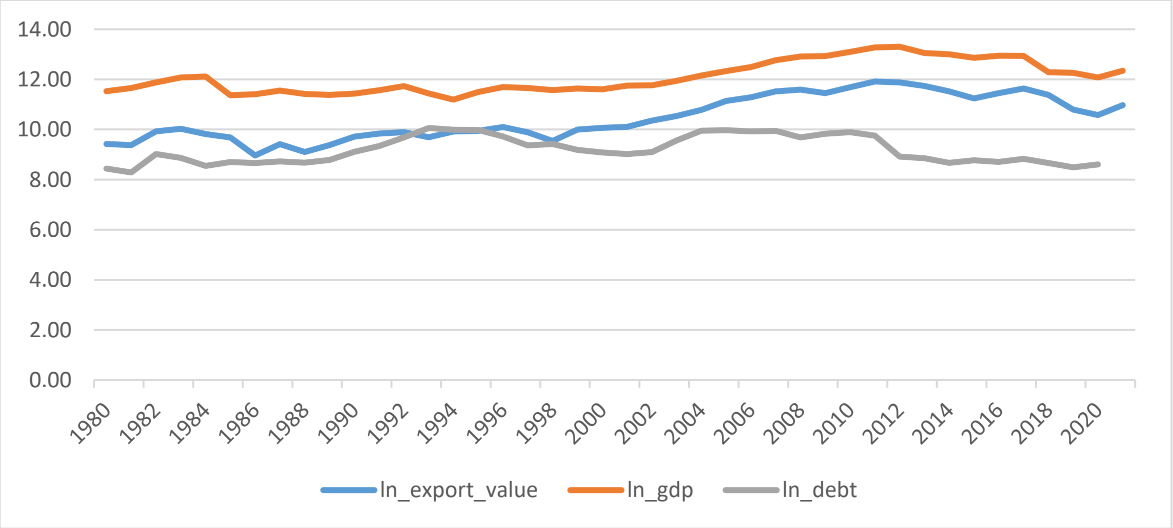
3.6.2 External debt

The external debt of Iran has been a matter of concern for the country's economy since the Iran-Iraq war. As evident from the Figure 3-7, the external debt increased sharply in the aftermath of the war and reached its peak in 1993. This debt burden was significant, considering the export revenue was less than the external debt in that year. It is crucial to note that the high external debt has negative implications for the country's economic growth, as evidenced by several studies.
(Safdari & Mehrizi, 2011) conducted a study that revealed a negative impact of external debt and imports on Iran's economic growth from 1974 to 2007. This finding highlights the importance of reducing external debt and dependence on imports to stimulate economic growth.
Furthermore, (Montazeri Shoorekchali & Eltejaei, 2021) studied the effects of external debt on economic growth in Iran and Malaysia. The study found a nonlinear correlation between the external debt size and economic growth in both countries. In Iran's case, the study concluded that external debt had a negative impact on economic growth. This result emphasizes the need to control external debt to achieve sustainable economic growth.
Moreover, the fluctuations in Iran's external debt from 1993 to 2010 suggest that the country faced challenges in managing its debt burden. However, since 2010, there has been

a decreasing trend in external debt, which is a positive development. Nevertheless, it is essential to note that reducing external debt should not come at the cost of compromising other economic indicators like investments, employment, and welfare.
In conclusion, the external debt of Iran has been a significant concern for the country's economy. The high external debt has negative implications for economic growth, as evidenced by various studies. Therefore, reducing external debt should be a priority for the government. However, it is crucial to manage the external debt in a way that does not negatively impact other economic indicators.



Source tradingeconomics
Figure 3-7 Iran external debt



Source: personal collection.
Figure 3-8 The time trend of relationship between GDP, debt and oil export revenue

The line chart in Figure 3-8 represents the relationship between the export value, GDP, and external debt of Iran over a period of 41 years, from 1980 to 2020 in natural logarithmic form. The data reveals that the export value and GDP of the country have generally increased over the years, indicating economic growth. However, the trend has been inconsistent with fluctuations observed in between. Despite this, there is a positive relationship between export value and GDP, suggesting that an increase in GDP is associated with an increase in export value.

The data also indicates that the level of external debt has fluctuated over the years, with a generally upward trend, indicating an increase in the level of debt over time. However, the trend has been more fluctuating in comparison to export value and GDP. Additionally, the data does not suggest a significant relationship between GDP or export value and external debt. There are periods where GDP and export value increase while external debt remains constant or increases, and vice versa.

To further investigate the relationship between crude oil export revenues and the government's GDP of Iran, univariate analysis can be used to determine whether there is any significant correlation. This could help to identify the extent to which crude oil exports are driving economic growth in the country. Moreover, multivariate regression analysis can be used to identify the relationship between crude oil revenues, GDP, and external debt. This method can help to identify any additional factors that are driving economic growth in Iran while accounting for other variables such as inflation and interest rates. Overall, further investigation using these statistical methods could provide more insights into the factors driving economic development in Iran and could inform policies aimed at promoting sustainable economic growth while managing external debt effectively.

4 Practical part

4.1 Univariate regression

A major objective of this research is to investigate whether there is any significant correlation between crude oil export revenues and the government's gross domestic product of Iran. The analysis will be performed using a linear regression model for this purpose.

$$y = b0 + b1x1 \quad \textit{Equation 4-1}$$

Where
Dependent variable (Y variable): Iran's GDP
To conduct the research, information on Iran's nominal GDP in current dollars will be employed to analyse the country's economic picture since this indicator measures Iran's actual economic situation.
Independent variable (x1 variable): crude oil export revenue
The export of oil will be investigated as part of this context. This thesis has already stated, in its earlier chapters, that crude oil is one of Iran's most widely traded commodities.
For the purpose of this linear regression analysis, the period to be analysed is the period between 1980 and 2020 for which explicit data are available on variables outlined in the previous paragraph.
In order to make the OLS technique applicable, it is necessary to test the assumptions of the linear regression model.

4.1.1 Linearity

The first assumption is that the time series process is in fact a linear process, wherein the parameters of the model are linear as well. It is usually used to test whether a relationship is accurately described by a model using the R2 coefficient.

Table 4-1 goodness of fit of univariuate model

Root MSE	38802	**R-Square**	0.9379
Dependent Mean	219394	**Adj R-Sq**	0.9363
Coeff Var	17.68600		

Table 4-2 Parameter Estimates of univariate model

Parameter Estimates						
Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	45784	9375.50995	4.88	<.0001
values_of_export_m	values_of_export_m	1	3.47347	0.14313	24.27	<.0001

R-square in table 4-1 is 0.94, which indicates that the variance of the oil export revenue explains 94% of the variance of the GDP variable.
Considering the P value of the export revenue in table 4-2, which is less than 0.05, it implies that oil exports are significant predictors of Iranian GDP. Moreover, As a result of the positive coefficient of export value, it can be seen that for every unit increase in the export value, there is an increase in the GDP of 3.47 million dollars as well.

4.1.2 Zero error term

It is expected that, given the explanatory variables for all the time periods for every t, the error U_t will be zero. Mathematically

$$\boldsymbol{E(Ut|X) = 0, \quad t = 1, 2, \dots, n}$$

Equation 4-2

To analyse zero error conditions in SAS, three tests are available by using the PROC UNIVARIATE tool: Student's t-test, Sign Test, and Wilcoxon Signed Rank Test.
The three tests produce a test statistic that indicates the null hypothesis, versus the two-sided alternative
H_0: $\mu_0=0$
H_1: $\mu_0\neq0$
As the table 4-3 shows, the p value greater than 0.05 , H_0 can’t be rejected and the condition of zero error term can be considered as satisfied.

Table 4-3 zero error test

Tests for Location: Mu0=0				
Test	Statistic		p Value	
Student's t	t	0	Pr > |t|	1.0000
Sign	M	-1.5	Pr >= |M|	0.7552
Signed Rank	S	9.5	Pr >= |S|	0.9038

4.1.3 Homoscedasticity

Due to this assumption, the variance of errors should be consistent for all observations, in other words the error term cannot depend on X.
H_0: $\sigma_i^2 = \sigma^2$
H_1: $\sigma_i^2 \neq \sigma^2$
As part of SAS' MODEL procedure, two tests are provided for testing heteroscedasticity of errors: the White's test and the modified Breusch-Pagan test. In this study, only the White's test considered.

Table 4-4 homoscedasticity test

Heteroscedasticity Test					
Equation	Test	Statistic	DF	Pr > ChiSq	Variables
GDP_m	White's Test	7.09	2	0.0289	Cross of all vars

As table 4-4 shows, P value of χ^2 test is less than 0.05, the null hypothesis of homoscedasticity is rejected and the variance of the errors are not stable over time. During the process of creating a data set, there is a possibility of inadvertently introducing heteroscedasticity. The y variable needs to be log-transformed in order to reduce some of the heteroscedasticity, and then an OLSR model should be built for log(y).
So the model is modified to

$$Ln(y) = b0 + b1 * ln(x1)$$ *Equation 4-3*

And check the linearity and zero error term again.

Table 4-5 goodness of fit of natural log model

Root MSE	0.21919	R-Square	0.8854
Dependent Mean	12.08651	Adj R-Sq	0.8825
Coeff Var	1.81348		

Table 4-6 paramerer estimates of log model

Parameter Estimates						
Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	4.97856	0.41088	12.12	<.0001
export_value	export_value	1	0.68043	0.03920	17.36	<.0001

Table 4-7 zero error test for natural log model

Tests for Location: Mu0=0				
Test	Statistic		p Value	
Student's t	t	0	Pr > |t|	1.0000
Sign	M	0.5	Pr >= |M|	1.0000
Signed Rank	S	14.5	Pr >= |S|	0.8536

The linearity and zero error condition met as we can see in table 4-6 and 4-7.
By using ln(y), the problem of heteroscedasticity solve. Table 4-8 shows the P value exceeding 0.05 indicates that the null hypothesis cannot be rejected and the variance of errors remains stable across time.

Table 4-8 homoscedasticity test of natural log model

Heteroscedasticity Test					
Equation	Test	Statistic	DF	Pr > ChiSq	Variables
ln_gdp	White's Test	0.82	2	0.6635	Cross of all vars

The assessment of the model assumption persists with the natural logarithm form of GDP.

4.1.4 Uncorrelated residuals

based on this assumption, the errors in two different time periods should be uncorrelated.

$$Corr(ut, us) \neq 0, for\ all\ t \neq s \quad \text{Equation 4-4}$$

There can be an error term that is not independent through time when using time series data in regression analysis. As a result, the errors are serially correlated (autocorrelated). In order to test for autocorrelation, the Durbin-Watson test is one of the most widely used methods. In SAS, the Durbin-Watson statistic of first order is displayed by default in the AUTOREG procedure at run time.
The hypothesis in this test are:
H_0: errors are serially uncorrelated
H_1: there are serial correlation among errors

Table 4-9 residual autocorrelation test for natural log model

Durbin-Watson Statistics			
Order	DW	Pr < DW	Pr > DW
1	0.9742	<.0001	0.9999

As o<DW<2 and the p value of autocorrelation is less than 0.05. Therefore, the null hypothesis is rejected that there is no serial correlation against the alternative of positive serial correlation.
So based on the table 4-9, this assumption is rejected.

4.1.5 Normality of residuals

If the residuals are normal, it means that the assumptions are valid and model inference(confidence intervals, model predictions) should also be valid.

Based on this assumption, There is no relationship between U_t errors and X, and they are distributed normally and independently $(0,\sigma^2)$.
H_0: the residuals are distributed normally
H_1: the residuals are not distributed normally.

Table 4-10 normality of residual test for log model

Tests for Normality				
Test	Statistic		p Value	
Shapiro-Wilk	W	0.975753	Pr < W	0.5197
Kolmogorov-Smirnov	D	0.106189	Pr > D	>0.1500
Cramer-von Mises	W-Sq	0.077669	Pr > W-Sq	0.2228
Anderson-Darling	A-Sq	0.452228	Pr > A-Sq	>0.2500

For number of observations less than 2000, the Shapiro-Wilk test is recommended by SAS. As the p value of Shapiro-Wilk test in table 4-10 is greater than 0.05, the hypothesis of normality of residuals can't be rejected and the residuals have normal distribution.
It is important to take into account unobserved trends that affect y_t that might also be correlated with the explanatory variables. Ignoring this possibility may result in spurious relationships between y_t and one or more explanatory variables.

4.1.6 Cointegration analysis

It is crucial to test for the existence of unit roots in the variables in most economic time series models, because they imply spurious relationships between variables. The Augmented Dickey Fuller (ADF) test is performed in order to determine whether or not the time series is stationarity, since it is a common and efficient method for determining unit roots.
H_0: the timeseries is Not stationarity
H_1: timeseries is stationarity
Since all the p-values are less than 0.05 in table 4-11, the null hypothesis can be rejected, and it can be concluded that the timeseries is stationary.

Table 4-11 unit root test for log model

Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	0	-19.6891	0.0009	-3.58	0.0007		
	1	-13.0403	0.0085	-2.59	0.0107		
Single Mean	0	-19.6789	0.0057	-3.53	0.0117	6.26	0.0162
	1	-13.0070	0.0463	-2.56	0.1093	3.36	0.2403
Trend	0	-20.1118	0.0349	-3.53	0.0494	6.24	0.0720
	1	-13.0670	0.2035	-2.50	0.3257	3.19	0.5565

Table 4-12 white noise test for residual in log model

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	25.95	6	0.0002	0.505	0.402	0.296	0.186	0.184	0.019
12	34.24	12	0.0006	-0.129	-0.166	-0.119	-0.213	-0.155	-0.139
18	50.51	18	<.0001	-0.221	-0.180	-0.171	-0.211	-0.184	-0.213
24	69.20	24	<.0001	-0.252	-0.259	-0.227	-0.147	-0.003	0.116

The autocorrelation check for white noise in table 4-12 shows that error terms are not white noise, so the model could be revised. Subsequently, a multivariate analysis will be conducted with an additional independent variable, namely external debt, to examine the relationship among these three variables.

4.2 Multivariate Regression

The effect of oil exports on Iranian economic growth is evaluated using multivariate timeseries regression. Using data available from 1980-2020, the following model is proposed:

$$GDPt \;=\; b0 + b1 * external\_debt_t + b2 * export\_Value_t + ut \qquad \text{Equation 4-5}$$

where the b1 and b2 are the parameters to be estimated and $\{u_t : t=1, 2, \ldots, n\}$ is the sequence of errors.

First of all model's assumptions, such as linearity, normality, and autocorrelation checked to ensure the model's validity.

4.2.1 Linearity

A high F-value and a low p-value (less than 0.05) suggest that the model has a significant linear relationship with the response variable. Additionally, the parameter estimates and their p-values provide information on the linear relationship between the predictor variables and the response variable. A significant parameter estimate (p-value less than 0.05) in table 4-14 suggests that there is a linear relationship between the predictor variable and the response variable.

Table 4-13 goodness of fit in multivariate log model

Root MSE	0.19834	R-Square	0.9086
Dependent Mean	12.08651	Adj R-Sq	0.9038
Coeff Var	1.64104		

Table 4-14 parameter estimates in multivariate log model

Parameter Estimates						
Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	6.38540	0.58637	10.89	<.0001
export_value	export_value	1	0.70812	0.03657	19.36	<.0001
ln_debt	ln_debt	1	-0.18455	0.05948	-3.10	0.0036

So we can write equation 4-6 as

$$GDPt \ = \ 6.39 - 0.18 * ln\_debt_t + 0.71 * export\_value_t + ut\ )$$ *Equation 4-6*

4.2.2 Zero error term

Given the explanatory variables for all time periods, the expected error u_t for each t is zero. P-value in the table 4-15 in all three cases are greater than 0.05 and we can’t reject the null hypothesis μ0=0 and so the zero error assumption is satisfied.

Table 4-15 zero error test in multivariate log model

Tests for Location: Mu0=0				
Test	Statistic		p Value	
Student's t	t	0	Pr > |t|	1.0000
Sign	M	-0.5	Pr >= |M|	1.0000
Signed Rank	S	21.5	Pr >= |S|	0.7844

4.2.3 Homoscedasticity

In the previous model, homoscedasticity was established. In this model, the test statistic equals 2.14 with 5 degrees of freedom, and a p-value of 0.8295 is obtained as we can see in table 4-16. Since the null hypothesis cannot be rejected, it is suggested that there is no significant evidence of heteroscedasticity in the residuals. The test was performed on the residuals obtained from the regression of GDP on external debt and oil value, and the variable "Cross of all vars" likely refers to the interaction term between external debt and oil value. Therefore, the test suggests that the residuals do not have significant heteroscedasticity and that the assumption of constant variance is not violated.

Table 4-16 homoscedasticity test for multivariate log model

Heteroscedasticity Test					
Equation	Test	Statistic	DF	Pr > ChiSq	Variables
ln_gdp	White's Test	2.14	5	0.8295	Cross of all vars

4.2.4 Uncorrelated residuals

One of the important assumption that should be checked is correlation between residuals. As we can see from table 4-17 the p-value=0.0014 shows that there is positive correlation between residuals. So the problem of serial correlation exists in this model.

Table 4-17 residuals autocorrelation test for multivariate log model

The AUTOREG Procedure

Ordinary Least Squares Estimates			
SSE	1.49493796	DFE	38
MSE	0.03934	Root MSE	0.19834
SBC	-8.2773058	AIC	-13.418022
MAE	0.15364067	AICC	-12.769373
MAPE	1.27705174	HQC	-11.546057
Durbin-Watson	1.2094	Total R-Square	0.9086

Durbin-Watson Statistics			
Order	DW	Pr < DW	Pr > DW
1	1.2094	0.0014	0.9986

4.2.5 Normality of residuals

normality of residuals can't be rejected and the residuals have normal distribution as can be seen in table 4-18.

Table 4-18 normality of residual in multivariate log model

Tests for Normality				
Test	Statistic		p Value	
Shapiro-Wilk	W	0.976808	Pr < W	0.5569
Kolmogorov-Smirnov	D	0.078526	Pr > D	>0.1500
Cramer-von Mises	W-Sq	0.027704	Pr > W-Sq	>0.2500
Anderson-Darling	A-Sq	0.219968	Pr > A-Sq	>0.2500

4.2.6 Cointegration analysis

We model several series in vector autoregressive models. Cointegration occurs when two nonstationary series are linearly combined, but the combination is stationary; the regression of one on the other is therefore not spurious, but rather tells us something about

the relationship between the two over time. A short-term dynamic model that is based on cointegration between two series is referred to as an error correction model (Wooldridge, 2012).
First of all, it is necessary to check the time series properties of the variables in order to be able to determine which specification is appropriate for the estimation of the VAR. In order to determine the order of integration for each variable, the Augmented Dickey-Fuller (1979) test is used. The non-stationary nature of the variables expressed in logs is inferred in this test as can be seen in tables 4-19, 4-20 and 4-21.
The table 4-19 is an Autocorrelation Check for White Noise for the residuals obtained from the multiple regression analysis. Looking at the Autocorrelations column, we can see that most of the autocorrelation values are relatively low and decrease as the lag increases. This suggests that there may be no strong autocorrelation in the residuals, and the residuals may be stationary.
However, it is important to note that this table alone is not a conclusive test for stationarity, and further analysis using methods such as the Augmented Dickey-Fuller (ADF) test is recommended to confirm the stationarity of the residuals.
Looking at the results, we can see that for the Zero Mean and Trend tests, both the lag 0 and lag 1 have p-values less than 0.05, indicating that we can reject the null hypothesis of the presence of a unit root, suggesting that the residuals are stationary. For the Single Mean test, the p-value for lag 0 is also less than 0.05, suggesting that we can reject the null hypothesis and the residuals are stationary. Therefore, based on the ADF test results, we can conclude that the residuals are stationary and suitable for use in a multiple regression analysis.
Based on the provided Dickey-Fuller Unit Root Tests results in table 4-20, it appears that the GDP time series may be non-stationary, as the p-values for all the test types (Zero Mean, Single Mean, and Trend) are greater than 0.05. In this case, all three test types have p-values greater than 0.05, indicating that the GDP time series may not be stationary. This suggests that further analysis, such as differencing or transformation, may be necessary to make the time series stationary before running a regression analysis with the independent variables.
Based on the Dickey-Fuller Unit Root Tests results in table 4-19 provided for external debt, it appears that the debt time series may be non-stationary. For the Zero Mean test, the p-value is 0.6775, which is greater than 0.05, indicating that we fail to reject the null hypothesis and suggesting that the external debt time series may not be stationary. For the Single Mean and Trend tests, the p-values are also greater than 0.05, suggesting that the external debt time series may not be stationary. Therefore, it is recommended to perform further analysis, such as differencing or transformation, to make the time series stationary before using it in a regression analysis with other independent variables.
Based on the Dickey-Fuller Unit Root Tests results provided for export value in table 4-21, it appears that the export value time series may be non-stationary. For the Zero Mean test, the p-value is 0.6980, which is greater than 0.05, indicating that we fail to reject the null hypothesis and suggesting that the export value time series may not be stationary. For the Single Mean and Trend tests, the p-values are also greater than 0.05, suggesting that the export value time series may not be stationary. Therefore, it is recommended to perform further analysis, such as differencing or transformation, to make the time series stationary before using it in a regression analysis with other independent variables.
the residuals obtained from the regression analysis were found to be stationary. This suggests that the non-stationarity of the original variables did not have a significant impact

on the regression results, and the model was able to capture the underlying relationships between the variables.

I use the Akaike Information Criterion (AIC) to determine the lag order in the VAR model. Various criteria and autocorrelation test indicate that 1 is an optimal lag length.

Table 4-19 stationarity test for external debt

stationarity test for debt

The ARIMA Procedure

Name of Variable = ln_debt	
Mean of Working Series	9.190074
Standard Deviation	0.537011
Number of Observations	41

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	65.25	6	<.0001	0.845	0.637	0.471	0.302	0.124	-0.017
12	76.88	12	<.0001	-0.145	-0.229	-0.269	-0.206	-0.124	-0.086
18	78.77	18	<.0001	-0.059	-0.045	-0.036	-0.024	-0.052	-0.126
24	144.90	24	<.0001	-0.219	-0.297	-0.344	-0.381	-0.404	-0.380

Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	0	0.0004	0.6775	0.00	0.6780		
Single Mean	0	-5.1852	0.3954	-1.69	0.4271	1.44	0.7100
Trend	0	-4.5532	0.8386	-1.47	0.8222	2.15	0.7536

Table 4-20 stationary test for GDP

stationarity test for gdp

The ARIMA Procedure

Name of Variable = ln_gdp	
Mean of Working Series	12.08651
Standard Deviation	0.631526
Number of Observations	41

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	161.04	6	<.0001	0.932	0.851	0.790	0.731	0.657	0.535
12	179.21	12	<.0001	0.419	0.325	0.218	0.094	-0.004	-0.070
18	209.56	18	<.0001	-0.125	-0.187	-0.244	-0.291	-0.325	-0.348
24	285.05	24	<.0001	-0.363	-0.366	-0.378	-0.387	-0.381	-0.354

Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	0	0.0375	0.6859	0.33	0.7745		
Single Mean	0	-2.7114	0.6801	-1.25	0.6423	0.86	0.8509
Trend	0	-3.7032	0.8945	-1.07	0.9220	0.83	0.9835

Table 4-21 stationarity test for oil export value

stationarity test for export_value

The ARIMA Procedure

Name of Variable = export_value	
Mean of Working Series	10.44624
Standard Deviation	0.873334
Number of Observations	41

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	168.88	6	<.0001	0.934	0.859	0.795	0.740	0.688	0.607
12	199.98	12	<.0001	0.503	0.405	0.306	0.214	0.139	0.071
18	215.92	18	<.0001	-0.013	-0.090	-0.153	-0.205	-0.242	-0.292
24	301.50	24	<.0001	-0.348	-0.369	-0.383	-0.402	-0.418	-0.433

Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	0	0.0912	0.6980	0.54	0.8283		
Single Mean	0	-2.6229	0.6914	-1.33	0.6078	1.10	0.7930
Trend	0	-4.5652	0.8377	-1.09	0.9183	1.00	0.9649

Table 4-22 stationarity test for multivariate log model

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	10.57	6	0.1027	0.380	0.249	0.088	0.044	0.138	-0.023
12	26.95	12	0.0079	-0.252	-0.318	-0.207	-0.260	-0.145	-0.066
18	29.01	18	0.0483	-0.144	-0.071	-0.052	-0.053	0.019	0.014
24	37.17	24	0.0421	-0.050	-0.108	-0.085	-0.013	0.135	0.209

Augmented Dickey-Fuller Unit Root Tests							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	0	-24.3304	0.0001	-4.06	0.0001		
	1	-17.9365	0.0016	-2.84	0.0056		
Single Mean	0	-24.3140	0.0011	-4.00	0.0033	8.02	0.0010
	1	-17.8175	0.0103	-2.79	0.0689	3.97	0.0985
Trend	0	-25.6692	0.0066	-4.15	0.0115	8.65	0.0115
	1	-19.2133	0.0439	-2.89	0.1774	4.19	0.3684

Table 4-23 Table Select lag based on AIC

	AIC
lag 1	-220
lag 2	-205.897
lag 3	-197.921
lag 4	-196.317
lag 5	-204
lag 6	-200

4.3 VAR model

In econometrics, VAR models are used to capture the evolution and interdependencies of multiple time series, generalizing the Univariate AR models. The model has one equation for each variable (Greene, 2002). Every variable in the VAR has its own lag as well as the lags of the other variables as in Equation 4-7 to 4-9.
The VARMAX procedure in SAS used for VAR model in this study.
The cointegration test here is based on (Johansen, 1995).
Based on the assumption that the error variables are distributed normally, Johansen's approach involves estimating the matrix (Γ - I) using a maximum likelihood estimation technique.
According to a number of authors, Johansen's Test can be considered a breakthrough over the Engle-Granger and Stock & Watson's tests. As a result, there is no need to select a dependent variable and no need to deal with errors that are carried over from one step to the next. Because of this, the test can detect multiple cointegrating vectors, which makes it a better method for multivariate analysis than Engle-Granger. Johansen's test also has the advantage of treating every test variable as an endogenous variable, which can be a very desirable feature.

The results in table 4-23 are for VAR(1) as we said in last part that 1 is optimal lag length.

Table 4-24 cointegration rank Johansen test

Cointegration Rank Test Using Trace						
H0: Rank=r	H1: Rank>r	Eigenvalue	Trace	Pr > Trace	Drift in ECM	Drift in Process
0	0	0.3554	31.2244	0.0336	Constant	Linear
1	1	0.1955	13.6603	0.0922		
2	2	0.1166	4.9597	0.0260		

Cointegration Rank Test Using Trace Under Restriction						
H0: Rank=r	H1: Rank>r	Eigenvalue	Trace	Pr > Trace	Drift in ECM	Drift in Process
0	0	0.3587	31.6802	0.1136	Constant	Constant
1	1	0.1970	13.9074	0.2951		
2	2	0.1204	5.1313	0.2692		

There is no separate drift in the error correction model in the "Cointegration Rank Test Using Trace" table, and the process has a constant drift before differencing, as indicated by Drift in Process. In the table entitled "Cointegration Rank Test Using Trace" the trace statistics and p-values for Case 3 are shown, while in the table entitled "Cointegration Rank Test Using Trace under Restriction" they are shown for Case 2.

Depending on the significance level, the Hypothesis Test of the Restriction determines whether Case 2 (the hypothesis H_0) or Case 3 (the hypothesis H1) are the appropriate results.

The table 4-24 shows that, we can reject H_0: R=0 in cointegration rank test using trace by significant level of 5% , because the P value(0.03) is less than 5% significant level which say there is not cointegration between variables. On null hypothesis R=1 and R=2 we quite sure the null hypothesis can't be rejected and there is cointegration between variables and there is at most two integrated process.

Hence, we can conclude that these three variables will be cointegrated in the long term, and there are two equations that could be used to describe this cointegration process.

$$\ln GDP_t = \mu 1 + \sum_{i=1}^{k} \Gamma_i \, lnGDP_{t-i} + \sum_{m=1}^{k} \Gamma_m ln(ext\_debt)_{t-m} + \sum_{n=1}^{k} \Gamma_n \, ln \, (\exp \, \_value)_{t-n} + u_{1t}$$

Equation 4-7

$$\ln ext\_debt_t = \mu 2 + \sum_{i=1}^{k} \Gamma_i \, lnGDP_{t-i} + \sum_{m=1}^{k} \Gamma_m ln(ext\_debt)_{t-m} + \sum_{n=1}^{k} \Gamma_n \, ln \, (\exp \, \_value)_{t-n} + u_{2t}$$

Equation 4-8

$$\ln exp \, \_value_t = \mu 3 + \sum_{i=1}^{k} \Gamma_i \, lnGDP_{t-i} + \sum_{m=1}^{k} \Gamma_m ln(ext\_debt)_{t-m} + \sum_{n=1}^{k} \Gamma_n \, ln \, (exp \, \_value)_{t-n} + u_{3t}$$

Equation 4-9

As we have VAR(1), we can write the model in matrix form as below

$$\begin{pmatrix} gdp \\ export \\ debt \end{pmatrix} = \begin{pmatrix} \mu_1 \\ \mu_2 \\ \mu_3 \end{pmatrix} + \begin{pmatrix} \Gamma_{11} & \Gamma_{12} & \Gamma_{13} \\ \Gamma_{21} & \Gamma_{22} & \Gamma_{23} \\ \Gamma_{31} & \Gamma_{32} & \Gamma_{33} \end{pmatrix} \begin{pmatrix} GDP_{t-1} \\ export_{t-1} \\ debt_{t-1} \end{pmatrix} + \begin{pmatrix} u_1 \\ u_2 \\ u_3 \end{pmatrix}$$

Equation 4-10

Table 4-25 parameter estimates of VAR model

Model Parameter Estimates						
Equation	Parameter	Estimate	Standard Error	t Value	Pr > |t|	Variable
ln_gdp	CONST1	0.64512	1.28080	0.50	0.6176	1
	AR1_1_1	0.76028	0.17300	4.39	0.0001	ln_gdp(t-1)
	AR1_1_2	0.12666	0.12886	0.98	0.3322	export_value(t-1)
	AR1_1_3	0.10247	0.07205	1.42	0.1636	ln_debt(t-1)
export_value	CONST2	-3.52572	1.56473	-2.25	0.0304	1
	AR1_2_1	0.47770	0.21135	2.26	0.0300	ln_gdp(t-1)
	AR1_2_2	0.57186	0.15742	3.63	0.0009	export_value(t-1)
	AR1_2_3	0.24463	0.08802	2.78	0.0086	ln_debt(t-1)
ln_debt	CONST3	2.73255	1.56419	1.75	0.0892	1
	AR1_3_1	-0.15389	0.21128	-0.73	0.4711	ln_gdp(t-1)
	AR1_3_2	0.02796	0.15737	0.18	0.8600	export_value(t-1)
	AR1_3_3	0.87393	0.08799	9.93	0.0001	ln_debt(t-1)

4.4 VECM

Models based on Vector Error Correction Mechanism (VECM) are particular applications of VARs or Vector Autoregressive Models. Error correction terms are introduced into VAR models during the specification of VECM models. VECM methodology is used if the variables in the system have a long-run relationship, that is, they are cointegrated.
Based on Johansen's test that is used to determine cointegrating relationships, short and long run coefficients and their associated Error Correction Models (ECMs) have been estimated whose orders have been chosen in accordance with AICs.
This can be described as a form of a restricted vector autoregression, such as that used for nonstationary cointegrated variables with an error correction factor.

Based on the table 4-26 we can write the equation 4-11

$$\begin{pmatrix} \Delta ln\ \_GDP \\ \Delta export\_value \\ \Delta ln\ \_debt \end{pmatrix} = \begin{pmatrix} 0.23 \\ -4.26 \\ 1.8 \end{pmatrix} + \begin{pmatrix} -0.23 & 0.16 & 0.091 \\ 0.50 & -0.37 & 0.22 \\ -0.12 & 0.09 & -0.15 \end{pmatrix} \begin{pmatrix} ln\ \_gdp(t-1) \\ ln\ \_export\_value(t-1) \\ ln\ \_debt(t-1) \end{pmatrix} \quad \text{Equation 4-11}$$

Table 4-26 parameter estimates for VECM(1)

The VARMAX Procedure

Type of Model	VECM(1)
Estimation Method	Maximum Likelihood Estimation
Cointegrated Rank	2

Model Parameter Estimates

Equation	Parameter	Estimate	Standard Error	t Value	Pr > |t|	Variable
D_ln_gdp	CONST1	0.23245	1.18377	0.20	0.8454	1
	AR1_1_1	-0.22515	0.16648	-1.35	0.1847	ln_gdp(t-1)
	AR1_1_2	0.15919	0.12115	1.31	0.1972	export_value(t-1)
	AR1_1_3	0.09127	0.06886	1.33	0.1934	ln_debt(t-1)
D_export_value	CONST2	-4.25664	1.47278	-2.89	0.0065	1
	AR1_2_1	0.50350	0.20713	2.43	0.0202	ln_gdp(t-1)
	AR1_2_2	-0.37052	0.15073	-2.46	0.0189	export_value(t-1)
	AR1_2_3	0.22479	0.08567	2.62	0.0127	ln_debt(t-1)
D_ln_debt	CONST3	1.88863	1.48895	1.27	0.2128	1
	AR1_3_1	-0.12410	0.20940	-0.59	0.5571	ln_gdp(t-1)
	AR1_3_2	0.09449	0.15239	0.62	0.5391	export_value(t-1)
	AR1_3_3	-0.14898	0.08661	-1.72	0.0940	ln_debt(t-1)

As we can see from table 4-26 The provided output shows the parameter estimates for a VARMAX(1) model with three equations: D_ln_gdp, D_export_value, and D_ln_debt. Starting with the equation for D_ln_gdp, the estimate for the constant term (CONST1) is 0.23245 with a large standard error of 1.18377, which indicates that the estimate is imprecise. The coefficient for the lagged dependent variable ln_gdp(t-1) (AR1_1_1) is -0.22515, which means that a one-unit increase in the lagged value of ln_gdp will decrease the current value of D_ln_gdp by 0.22515 units. However, the estimate is not significant at the 5% level, as the p-value (Pr > |t|) is 0.1847, which is greater than 0.05. The coefficients for the lagged values of export_value and ln_debt (AR1_1_2 and AR1_1_3) are positive, but again, they are not significant at the 5% level.

Moving to the equation for D_export_value, the estimate for the constant term (CONST2) is -4.25664, which means that the expected value of D_export_value when all the other variables are zero is -4.25664. The coefficient for the lagged dependent variable ln_gdp(t-1) (AR1_2_1) is positive and significant at the 5% level, which means that a one-unit increase in the lagged value of ln_gdp will increase the current value of D_export_value by 0.50350 units. The coefficient for the lagged value of export_value (AR1_2_2) is negative and significant at the 5% level, which means that a one-unit increase in the lagged value of export_value will decrease the current value of D_export_value by 0.37052 units. The coefficient for the lagged value of ln_debt (AR1_2_3) is positive and significant at the 5%

level, which means that a one-unit increase in the lagged value of ln_debt will increase the current value of D_export_value by 0.22479 units.
Finally, for the equation of D_ln_debt, the estimate for the constant term (CONST3) is 1.88863 with a standard error of 1.48895, which means that the estimate is imprecise. The coefficient for the lagged dependent variable ln_gdp(t-1) (AR1_3_1) is negative, but it is not significant at the 5% level. The coefficient for the lagged value of export_value (AR1_3_2) is positive, but it is not significant at the 5% level. The coefficient for the lagged value of ln_debt (AR1_3_3) is negative, but it is only marginally significant at the 10% level.
Overall, the parameter estimates suggest that the lagged values of ln_gdp, export_value, and ln_debt have significant impacts on the current values of D_ln_gdp, D_export_value, and D_ln_debt. However, some of the estimates are not significant at the 5% level, and some have large standard errors, which means that they are imprecise. Therefore, further analysis is needed to evaluate the significance and reliability of the estimates.
table 4-27 shows the parameter estimates for the Alpha and Beta coefficients of a VECM(1) model. The Beta parameters correspond to the long-run or equilibrium relationships between the variables, while the Alpha parameters represent the short-run dynamics that adjust the system back to its long-run equilibrium after a shock.
Starting with the equation for D_ln_gdp, the estimate for Beta1_1 is 4.88481, which means that in the long run, a one-unit increase in ln_gdp will lead to an increase of 4.88481 units in D_ln_gdp. Similarly, the estimate for Beta1_2 is -1.90342, which means that in the long run, a one-unit increase in ln_debt will lead to a decrease of 1.90342 units in D_ln_gdp. The estimates for the Alpha coefficients (ALPHA1_1 and ALPHA1_2) indicate that the short-run adjustment of D_ln_gdp to deviations from the long-run equilibrium is not significant for the lagged values of Beta1_1 or Beta1_2.
Moving to the equation for D_export_value, the estimate for Beta2_1 is -3.57755, which means that in the long run, a one-unit increase in export_value will lead to a decrease of 3.57755 units in D_export_value. Similarly, the estimate for Beta2_2 is 1.32534, which means that in the long run, a one-unit increase in export_value will lead to an increase of 1.32534 units in D_export_value. The estimates for the Alpha coefficients (ALPHA2_1 and ALPHA2_2) indicate that the short-run adjustment of D_export_value to deviations from the long-run equilibrium is significant only for the lagged value of Beta2_1.
Finally, for the equation of D_ln_debt, the estimates for the Beta coefficients (Beta3_1 and Beta3_2) indicate that in the long run, both ln_debt and ln_gdp have a positive impact on D_ln_debt. The estimates for the Alpha coefficients (ALPHA3_1 and ALPHA3_2) indicate that the short-run adjustment of D_ln_debt to deviations from the long-run equilibrium is not significant for the lagged values of Beta3_1 or Beta3_2.
Overall, the estimates suggest that the variables have significant long-run relationships, which are captured by the Beta coefficients. However, the short-run dynamics, captured by the Alpha coefficients, are not significant in most cases, which suggests that the system adjusts quickly to deviations from the long-run equilibrium.

Table 4-27 Parameter estimates of VECM model

Alpha and Beta Parameter Estimates						
Equation	Parameter	Estimate	Standard Error	t Value	Pr > |t|	Variable
D_ln_gdp	ALPHA1_1	-0.01375	0.03176	-0.43	0.6676	Beta[,1]'*_DEP_(t-1)
	ALPHA1_2	0.08300	0.03176	2.61	0.0130	Beta[,2]'*_DEP_(t-1)
	BETA1_1	4.88481				ln_gdp(t-1)
	BETA1_2	-1.90342				ln_gdp(t-1)
D_export_value	ALPHA2_1	0.11309	0.03951	2.86	0.0070	Beta[,1]'*_DEP_(t-1)
	ALPHA2_2	0.02569	0.03951	0.65	0.5196	Beta[,2]'*_DEP_(t-1)
	BETA2_1	-3.57755				export_value(t-1)
	BETA2_2	1.32534				export_value(t-1)
D_ln_debt	ALPHA3_1	-0.04584	0.03994	-1.15	0.2587	Beta[,1]'*_DEP_(t-1)
	ALPHA3_2	-0.05244	0.03994	-1.31	0.1976	Beta[,2]'*_DEP_(t-1)
	BETA3_1	1.67490				ln_debt(t-1)
	BETA3_2	1.37703				ln_debt(t-1)

4.5 Orthogonal impulse response analysis

The orthogonalized impulse response function provides a useful tool for understanding the dynamic interrelationships among the variables in the model and the potential effects of shocks to one variable on the others.

The response to orthogonalized impulse in export_value tells us how much the other variables (i.e., ln_gdp and ln_debt) respond to a one-unit shock in export_value while controlling for the effects of their own shocks and the shocks from other variables.

Looking at the Figure 4-1 of orthogonalized impulse response, we can see that a one-unit shock to export_value leads to a positive response in ln_gdp and ln_debt in the short run. Specifically, in the first period after the shock, ln_gdp increases by 0.21196, and ln_debt increases by 0.22635, both with statistical significance at the 5% level. In the long run, the response of ln_gdp and ln_debt to a shock in export_value becomes larger, indicating that the effect of the shock persists over time. However, we should note that these responses are obtained after controlling for the effects of shocks from other variables, which may confound the direct effect of export_value on the other variables.

The response to an orthogonalized impulse in ln_gdp in Figure 4-2 shows how the other variables in the system respond to a one-time shock in ln_gdp, holding all other variables constant. The table shows that the response of ln_gdp to its own shock is positive and gradually increases over time, indicating that the shock has a positive and persistent effect on the variable. The response of export_value to ln_gdp shock is positive and increases over time, suggesting that the shock has a positive and persistent effect on exports. The response of ln_debt to ln_gdp shock is positive but relatively small, suggesting that the shock has a limited effect on debt.

The response to orthogonalized impulse in ln_debt in Figure 4-3 tells us about the dynamic relationship between ln_debt and the other variables in the model, after controlling for the effects of their own shocks. Specifically, it shows the accumulated effect of a one-

standard-deviation shock to ln_debt on the other variables in the model over time, while holding constant the effects of the shocks to ln_gdp and export_value.
Looking at the results, we can see that a shock to ln_debt has a relatively small and insignificant impact on ln_gdp and export_value over the first several periods, but its impact becomes more pronounced in later periods. This suggests that the effect of a shock to ln_debt on these variables is delayed and cumulative, rather than immediate.

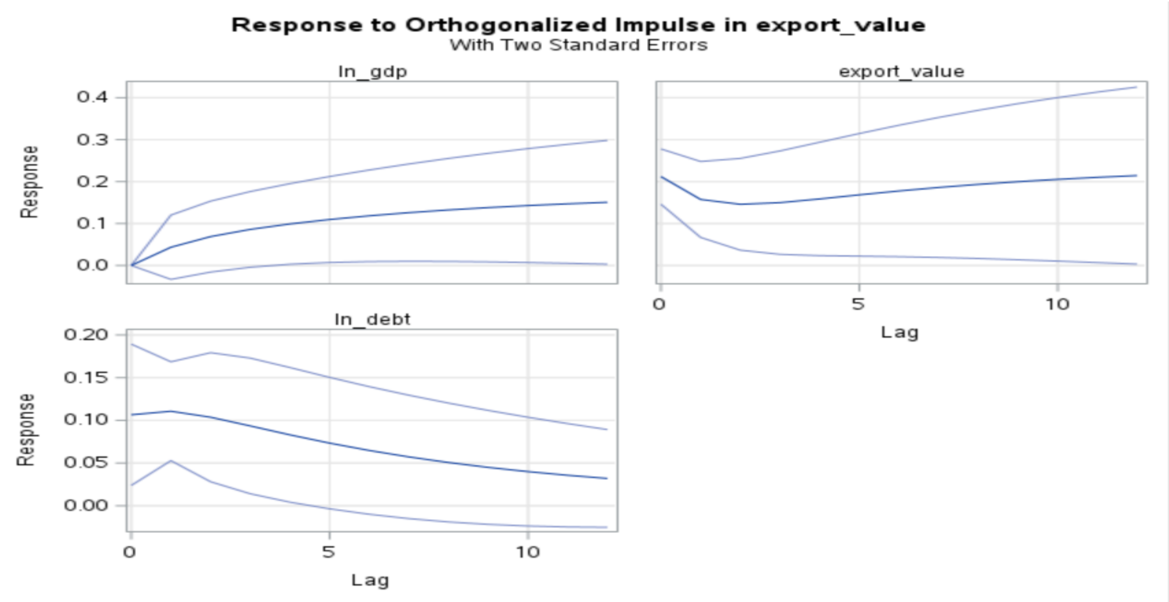


Figure 4-1 Response to orthogonalized impulse in export value

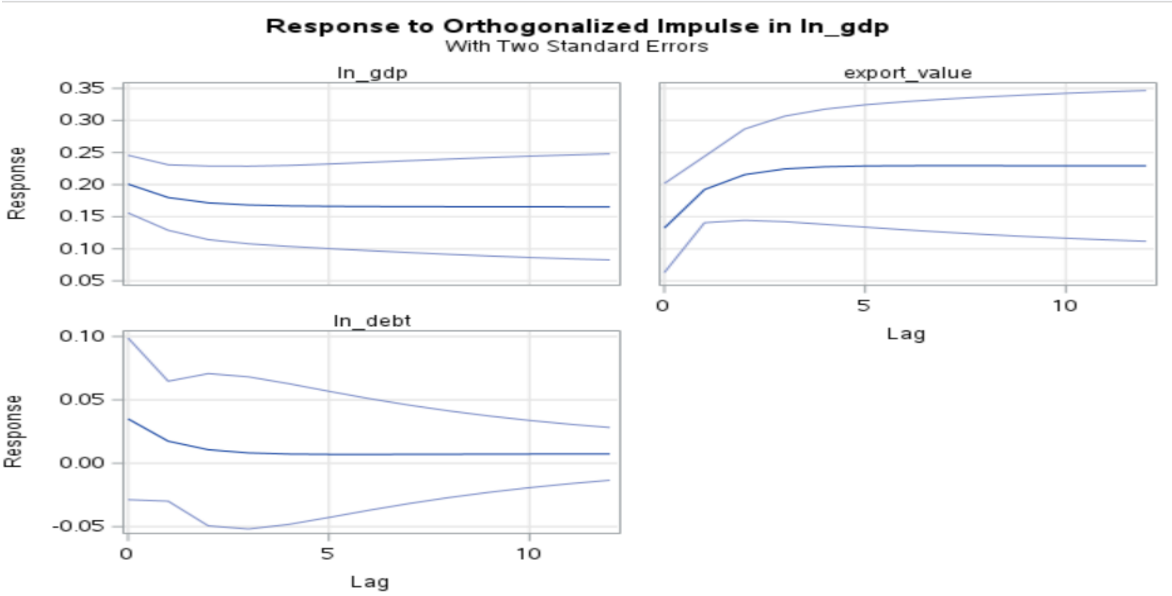


Figure 4-2 Response to orthogonalized impulse in GDP

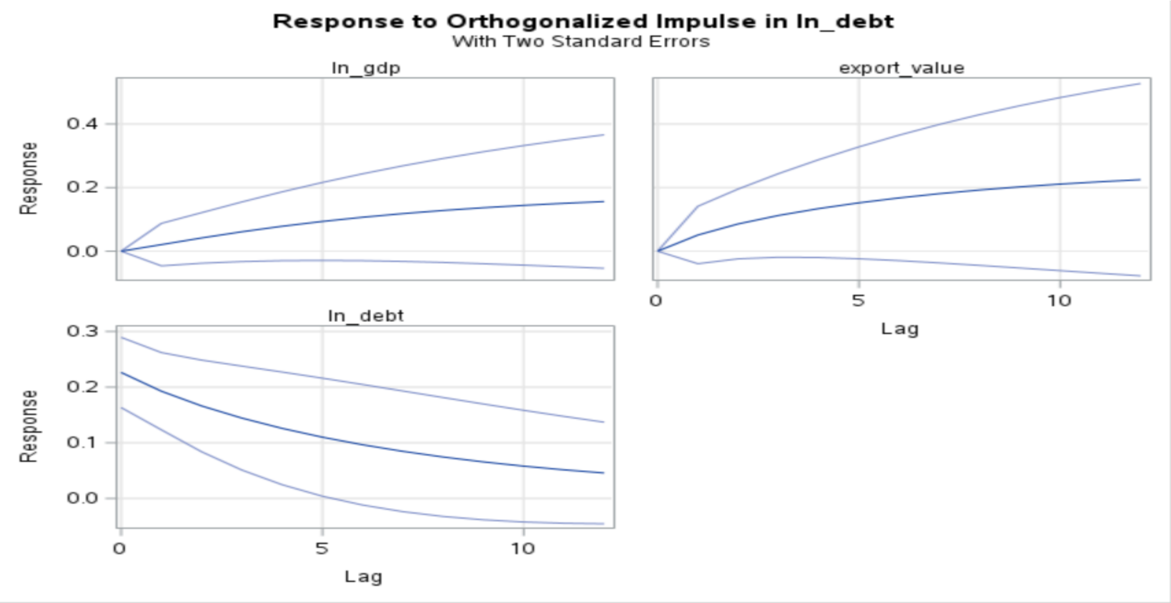


Figure 4-3 Response to orthogonalized impulse in external debt

5 Results and Discussion

The multivariate regression was performed to investigate the relationship between GDP, external debt, and export value. The results of the regression analysis are presented in part 4. The multivariate regression results suggest that external debt has a negative impact on GDP, while export value has a positive impact. Specifically, a 1% increase in external debt is associated with a 0.18% decrease in GDP, while a 1% increase in export value is associated with a 0.71% increase in GDP. The coefficient estimates are statistically significant at the 5% level.
However, it should be noted that the multivariate regression model assumes that the variables are not related in the long run. This assumption may not hold in the case of cointegrated variables, which is why we also performed VAR and VECM analyses.
The VAR analysis suggests that the lagged values of GDP, external debt, and export value have significant impacts on the current values of the variables. However, some of the estimates are not significant at the 5% level, and some have large standard errors, which means that they are imprecise. The parameter estimates for the VAR model are used to estimate the VECM, which captures the long-run relationships between the variables.
The VECM results suggest that the variables have significant long-run relationships. Specifically, a one-unit increase in GDP leads to an increase of 4.88 units in GDP in the long run, while a one-unit increase in external debt leads to a decrease of 1.90 units in GDP. Additionally, a one-unit increase in export value leads to a decrease of 3.58 units in export value and an increase of 1.33 units in GDP in the long run.
The short-run adjustment of the variables to deviations from the long-run equilibrium is not significant in most cases, which suggests that the system adjusts quickly to deviations from the long-run equilibrium.
Overall, the findings of the multivariate regression, VAR, and VECM analyses suggest that the external debt has a negative impact on GDP, while export value has a positive impact. However, the short-run dynamics, captured by the Alpha coefficients in the VECM, are not significant in most cases, which suggests that the system adjusts quickly to deviations from

the long-run equilibrium. These results provide insights for policymakers in developing countries who are concerned with managing external debt and promoting exports as a means of boosting economic growth.

6 Conclusion

Iran is a big country with a complicated economy and political and geographical situation. in this study the relationship between oil revenue and GDP and external debt were analysed. In the practical part, annual data set on the interdependency between oil export revenue and GDP over the period 1980–2020 were analysed, Moreover relationship between oil exports, GDP and external debt are tested for cointegration and long run relationship by VAR model. it can be concluded that oil export revenue has a positive and significant effect on Iran's GDP. This suggests that the Iranian economy heavily relies on its oil export revenue and the fluctuations in the oil market can have a significant impact on the country's economy.

On the other hand, external debt has a negative and significant effect on Iran's GDP, indicating that the accumulation of external debt is not beneficial for the country's economic growth. This is likely due to the fact that the servicing of external debt requires a substantial amount of resources, which could otherwise be invested in productive activities.

Additionally, the analysis suggests that the effect of external debt on Iran's GDP is more pronounced in the short run, while the effect of oil export revenue is more persistent in the long run. This highlights the importance of considering both short-run and long-run effects in economic analysis.

The impact of sanctions on Iran's GDP and external debt cannot be ignored. Sanctions have had a significant negative impact on Iran's economy, particularly in recent years. The U.S. sanctions on Iran's oil exports, which were reimposed in 2018, have significantly reduced Iran's oil revenue, which in turn has led to a decrease in government revenues and GDP. The decrease in oil revenue has also made it difficult for Iran to service its external debt. With reduced oil revenue, Iran has had to rely on other sources of revenue to pay off its debt, such as non-oil exports and foreign investment. However, the effectiveness of these alternative sources has been limited, and Iran has struggled to meet its debt obligations.

In addition to reducing Iran's revenue and increasing its debt burden, sanctions have also had other negative effects on Iran's economy, such as causing inflation, increasing unemployment, and reducing investment. As a result, the impact of sanctions on Iran's economy cannot be ignored when examining the relationship between oil exports, GDP, and external debt. Overall, the combination of sanctions and the volatility of oil prices have made it difficult for Iran to maintain a stable and sustainable economy. To address these challenges, Iran may need to pursue economic reforms and diversify its economy away from reliance on oil exports.

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8 Appendix

1980-2021.xlsx
multivariate_reg.sas
univariate_reg.sas
univariate_reg-ln.html
VAR(1)
VECM(1)