The Impact of Economic Policy Uncertainty on Energy Prices, Financial Stability and Consumption-base Carbon Emissions

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ABSTRACT

This thesis investigates the impact of Economic policy uncertainty on energy prices, financial stability and consumption-based carbon emissions. The second chapter of this thesis employed multivariate DCC-GARCH models to examine the interconnection between natural gas price, crude oil prices and Russian economic policy uncertainty (REPU) for the period of 1994-2019. The findings indicate strong interconnections natural gas prices, crude oil price and REPU. The findings further revealed that the interconnection between REPU and natural gas is more than that of between REPU and crude oil price. Moreover, the correlation between REPU and natural gas prices is higher, followed by the correlation between REPU and crude oil price. Energy prices follows similar pattern, they both increase and decrease at the same period. The findings further indicates that crucial global events like 2008 global crisis, 9/11 terrorist attack and 2014-2017 Russian financial crisis has significant impact on the interconnections between REPU and energy prices.

The thesis further utilized the Mean Group (MG) estimators, the Augmented Mean Group (AMG) estimators, and the Common Correlated Effects Mean Group (CCFMG) estimators to investigate the influence of United State economic policy uncertainty (US EPU) on BRICS financial stability for the period of 2003-2020. The findings of the chapter revealed that US EPU is insignificant to BRICS financial stability, the findings further indicates that and increase in trade openness, gross domestic product per capita and gross capital formation increases financial stability. Conversely, increase in exchange rate, inflation rate and domestic credit to private sector decreases financial stability.

Moreover, the thesis applied Panel Autoregressive Distributive Lag (ARDL) Model to investigate the impact of Economic Policy Uncertainty (EPU) and Foreign Direct Investment (FDI) on Consumption-based Carbon Emissions (CCO2 emissions) a case study of G7 countries for the period of 1994-2020. The findings shows that an increase in EPU decreases CCO2 emissions, while increase in FDI improves CCO2 emissions. Furthermore, Domestic investment (DI) and Gross Domestic Product per Capita (GDP) enhances CCO2 emissions, while Portfolio Investment (PI) negatively impact CCO2 emissions.

Keywords: economic policy uncertainty, energy prices, financial stability and consumption-based carbon emissions.

ÖZ

Bu tez, Ekonomi politikası belirsizliğinin enerji fiyatları, finansal istikrar ve tüketime dayalı karbon emisyonları üzerindeki etkisini incelemektedir. Bu tezin ikinci bölümünde, 1994-2019 dönemi için doğal gaz fiyatı, ham petrol fiyatları ve Rus ekonomik politikası belirsizliği (REPU) arasındaki bağlantıyı incelemek için çok değişkenli DCC-GARCH modelleri kullanılmıştır. Bölümün bulguları, doğal gaz fiyatları, ham petrol fiyatları ve REPU'nun güçlü arabağlantılarına işaret etmektedir. Bulgular ayrıca REPU ile doğal arasındaki bağlantının, REPU ile ham petrol fiyatı arasındaki bağlantıdan daha fazla olduğunu ortaya koydu. Ayrıca REPU ile doğalgaz fiyatları arasındaki korelasyon, REPU ile ham petrol fiyatları arasındaki korelasyondan daha yüksek, REPU ile enerji fiyatları arasındaki korelasyon da benzer bir seyir izliyor, aynı dönemde hem artıyor hem de azalıyor. Bulgular ayrıca 2008 küresel durgunluğu, 9/11 terör saldırısı ve 2014-2017 Rusya mali krizi gibi önemli küresel olayların REPU ve enerji fiyatları arasındaki bağlantılar üzerinde önemli etkisi olduğunu gösteriyor.

Üçüncü bölüm, Amerika Birleşik Devletleri ekonomik politikası belirsizliğinin (US EPU) BRICS finansal istikrarı üzerindeki etkisini araştırmak için Ortalama Grup (MG) tahmin edicileri, Artırılmış Ortalama Grup (AMG) tahmin edicileri ve Ortak İlişkili Etkiler Ortalama Grubu (CCFMG) tahmin edicilerini kullanmıştır. 2003-2022 dönemi için. Bölümün bulguları, ABD EPU'daki artışın BRICS finansal istikrarını azalttığını ortaya koyarken, bulgular ticari açıklık, kişi başına gayri safi yurtiçi hasıla ve brüt sermaye oluşumundaki artışın finansal istikrarı artırdığını göstermektedir.

Buna karşılık, döviz kuru, enflasyon oranı ve özel sektöre verilen yurt içi kredilerdeki artış finansal istikrarı azaltmaktadır.

Dördüncü Bölüm, Ekonomik Politika Belirsizliğinin (EPU) ve Doğrudan Yabancı Yatırımın (FDI) Tüketime Dayalı Karbon Emisyonları (CCO2 emisyonları) üzerindeki etkisini araştırmak için uygulanan Panel Otoregresif Dağılım Gecikmesi (ARDL) Modeli, 1994 dönemi için G7 ülkelerinin bir vaka çalışması -2020. Dördüncü bölümün bulguları, EPU'daki artışın CCO2 emisyonlarını azalttığını, DYY'deki artışın ise CCO2 emisyonlarını iyileştirdiğini göstermektedir. Ayrıca, Yurtiçi yatırım (DI) ve Kişi Başına Gayri Safi Yurtiçi Hasıla (GSYİH), CCO2 emisyonlarını artırırken, Portföy Yatırımı (PI) CCO2 emisyonlarını azaltır.

Anahtar Kelimeler: ekonomi politikası belirsizliğinin, enerji fiyatları, finansal istikrar, tüketime dayalı karbon emisyonları.

DEDICATION

To the entire family of Alhaji Hamza Ibrahim Ringim

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LIST OF ABBREVIATIONS

ADF	Augmented Dickey-Fuller
AMG	Augmented Mean Group
ARDL	Autoregressive Distributive Lag Model
CADF	Cross-sectional Augmented Dickey-Fuller
CCGM	Common Correlation Mean Group
CCO2	Consumption-based Carbon Emissions
CD	Cross-sectional Dependency
CDCC	Corrected Dynamic Conditional Correlation
CF	Gross Capital Formation
CIPS	Cross-sectional Im, Pesaran, and Shin
CO2	Carbon Emissions
DC	Domestic Credit to Private s
DI	Domestic Investment
DOLS	Dynamic Ordinary Least Square
EPU	Economic Policy Uncertainty
EXC	Exchange Rate
FDI	Foreign Direct Investment
FMOLS	Fully Modified Ordinary Least Square
GARCH	Generalized Auto Regressive Conditional Heteroskedasticity
GDP	Gross Domestic Product
GDPPC	Gross Domestic Product Per Capita
IEA	International Energy Association
INF	Inflation Rate

LPG	Liquidized Natural Gas
MG	Mean Group
NGPRICE	Natural Gas Price
OILPRICE	Crude Oil Price
PI	Portfolio Investment
PP	Philips-Perron
R&D	Research and Development
REPU	Russian Economic Policy Uncertainty
RETREPU	Return on Russian Economic Policy Uncertainty
SIC	Schwarz Information Criterion
TO	Trade Openness
OECD	Organization for Economic Co-operation and Development.
ECM	Error Correction Model
PMG	Pooled Mean Group

Chapter 1

INTRODUCTION

1.1 Background and Motivation of the Study

The contemporary world has been experiencing series of events over the past few decades. Political decisions become more difficult with uncertainty, as the policy makers are uncertain about the results and the economic consequences of their decision. Baker et al (2016) formulated the Economic Policy Uncertainty (EPU) index by making use of newspapers coverage counts. Hence, policy makers can use the EPU index trend in order to better predict the possible outcome of their economic and political decisions.

Since the formulation of EPU index several scholarly studies have investigated the interconnection between EPU and recovery, corporate investment, stock market volatility, banks' loan price, financial stability economic growth and energy consumption (Baker et al. 2012, Wang and Huang 2014, Liu et al. 2015, Beckmann and Czudaj 2017, Ashraf and Shen, Phan et al. 2021). Therefore EPU index is an essential tool to be considered by the policy makers in both political and economic decisions. EPU is a volatile index that requires a significant consideration by policy makers and academics.

Economic policy uncertainty is considered as the unanticipated risk related to government policies and regulations. This situation resulted to market uncertainty due to reduction in both individual consumptions and business investments as a result of increase in risk caused by economic policy uncertainty (Baker et al., 2016). Therefore, uncertainty about government decisions is associated with risk and economic consequences on both macro and micro economic variables, such as taxes, inflation rate and unemployment. EPU index is crucial to macroeconomic performance of a country, hence, is paramount to understand the dynamic of EPU index in making the right decision about consumption and investment by household and firms. According to economic policy uncertainty index formulated by (Baker et al., 2014), some historical events like 2008 global recession, 9/11 terrorist attack and the recently Covid-19 global pandemic indicate significant increase in the EPU index.

Crude oil and natural gas are crucial in the modern world as they remain the major source of energy, revenue and employment to many countries. The impact of oil and gas are beyond the energy sector, but other sectors heavily rely on the oil and gas, sectors like manufacturing, transportation and services cannot progress without oil and gas. Therefore, oil and gas price are crucial to the global economy as they play a significant role in determining the demand and supply of crude oil and natural gas. Hence, oil and gas prices have a great influence directly or indirectly to both domestic and international economy. Financial stability is an attribute of a financial system to be resilience to both anticipated and unanticipated shock that can directly or indirectly affect the financial structure which further affect the economy at large. Therefore, financial stability is important to domestic and global economy in general. Consumption-based carbon emissions are domestic or regional carbons that are adjusted for international trade. Therefore, carbon is transferred among producing and consuming nations or regions. Hence consumption-based carbon emission is crucial to environment and climate.

Considering the crucial role of EPU index, energy prices, financial stability, environment quality and climate change on both domestic and international economy, it is important to investigate the impact of economic policy uncertainty on energy prices, financial stability and consumption-base carbon emissions. This thesis investigate the interconnection between Russia EPU index and energy prices, the thesis further investigate the influence of US EPU index on BRICS countries financial stability, moreover the thesis also examine the impact of G7 EPU index and FDI on consumption-based carbon emissions.

All the three chapters included in this thesis revolve around BRICS and G7 countries. The selection of the countries is according to their role in both regional and international economic and political system. The first chapter is a country-based time series study, a case study of Russia. The chapter explores the relationship between EPU and energy price using Multivariate DCC-MGARCH Models. Russia is selected based on the country's crucial role in .energy markets. The time span of the research is between the periods of 1994 to 2019, during this period the global energy price prices has experience series of fluctuations, some of the fluctuations are related to economic and political decisions by key players in the sector, while some fluctuations are due to natural causes. Some major global events occurred within the period of the study, these events includes, the 2009 world recession, the Russia financial crisis which lasted for about four years (2014-2017), the September 11 terrorist attack and the Russia taking over of Crimea from Ukraine. All the above mentioned events significantly influence the interconnection among Russia EPU index and energy prices. The second chapter of this thesis examines the effect of USA EPU index on BRICS countries financial stability. USA EPU is vital to every country because of USA's role in the global economy. The 2008 global financial crises were rooted from the USA, and were later spread to other countries. Therefore, USA economy is important to BRICS economies. Hence, US EPU index is as important as the global EPU index. We also consider the relationship between USA and BRICS countries in terms of production, foreign direct investment and trade. We apply second generation panels data analysis, we used Mean Group (MG), Augmented Mean Group (AMG) and Common Correlation Mean Group (CCGM) estimator to investigate the influence of USA EPU index, trade openness, GDP, exchange rate, inflation, domestic credit to private sector and gross capital formation on BRICS financial stability.

The fourth chapter investigates the role of G7 countries' specific EPU index, Foreign Direct Investment (FDI) and other control variables on consumption-based carbon emissions (CCO2) for the period of 1994 to 2020. Carbon Emission (CO2) is usually measured as production or territorial base emissions; this area has been attracting so much attention from academia and policy makers due to the importance of environment quality in our contemporary world. The world is currently facing many problems due to climate change, In 2020 China and USA are ranked as the highest polluters in the world, the two countries released about 10.6 and 4.7 billion metric tons of CO2 respectively (Statista, 2022). Recently, the CO2 is adjusted by subtracting export and adding import to the traditional CO2, which results to the consumption-based carbon emissions (Global Carbon Project, 2022). With the new discovery of the CCO2, the area has been attracting a lot of attention by researchers.

Chapter four applied the second generation panel ARDL technique to investigate both short-run and long-run interconnection among EPU, FDI and CCO2.

1.2 Aims and Objectives of the Research

The role of economic policy uncertainty on energy prices, financial stability and consumption-based carbon emissions has not been widely investigated. The current thesis is aimed at investigating the interconnection between energy prices and economic policy uncertainty, a case study of Russia. The thesis is also aimed at investigating the influence of US economic policy uncertainty on BRICS economies financial stability. Furthermore, the thesis is also aimed at investigating the impact of economic policy uncertainty and foreign direct on consumption-based carbon emissions in G7 nations.

Derived from the background of the study the objectives of the current thesis are as follows:

1. The data for REPU will be extracted from the website of economic policy uncertainty index and the data for energy prices will be extracted from the British Petroleum (BP) Statistical Review of World Energy, the data span is 1994-2019. The thesis will further employ multivariate DCC-GARCH MODELS to check the dynamics of REPU in both natural gas and crude oil in Russia.
2. Moreover, the current thesis will also employ US EPU index dataset from the economic policy uncertainty website. The data for bank z-score will be source from FRED Economic data, trade openness, gross domestic product per capita, exchange rate, inflation rate, domestic credit to private sector and gross capital formation will be extracted from World Bank development

indicators. All dataset are for the period of 1994-2020. Furthermore, the thesis will utilize the MG, AMG and CCFMG models to examine how US EPU index influences the financial stability of BRICS.

3. Furthermore, the data for G7 countries' specific EPU will be sourced from the economic policy uncertainty website, the data for consumption-based carbon emissions OECD website. The dataset for FDI, DI, PI, and GDPPC will be sourced from World Bank's development indicators. All dataset spans for the period of 1994-2020, the thesis will apply the panel ARDL model to investigate how EPU and FDI affect CCO2 emissions in the G7 countries.

This thesis will also provide answers to the following questions.

1. What are the interconnections between Russia EPU index and crude oil and natural gas prices?
2. What is the impact of USA EPU index on BRICS financial stability?
3. Does G7 countries' specific EPU index affects consumption-based carbon emissions?
4. What is the role of FDI on consumption-based carbon emissions?
5. What are the effects of G7's FDI inflows and portfolio investment on consumption-based carbon emissions?

1.3 Outline of the Thesis

The next chapter studied the interconnection between Russia EPU index and energy price. The chapter compromise of the introduction section, the literature review is presented in section 2, section 3 entails the methodology and the expiations of data, expiations of the results, and the last section is the conclusion. Chapter three examines the influence of US EPU index on BRICS economies financial stability, the chapter includes five section of introduction, review of previous studied, the methodology applied in the study, discussions of the findings and the conclusion. The fourth chapter investigates the role of EPU index on CCO2 Emissions in G7 countries. The chapter has five sections, sections one is the introduction, review of previous studies is presented in section two. Methodology and data are presented in section 3, section four is the outcomes and the discussion, the final section is conclusion and policy implications

Chapter 2

ECONOMIC POLICY UNCERTAINTY AND ENERGY PRICES: EVIDENCE FROM RUSSIA

2.1 Introduction

A few years ago, various considerable challenges have developed, which led to international economic and political uncertainty. These start with the “Arab Spring” that emanate to political unrest in the Middle East and amidst the global forces, and concluded with the election of Donald Trump as the President of the United States, which is a calling of extensive adjustment in the world status quo. As the world proceeds to expand at an expeditious step, this adjustment produce perceives economic and political instability, enhancing uncertainty globally. In Europe, the relationship among countries has been distracted due to an increase in terror threats and an increase in the right-wing political philosophy, which is a result of events like refugees moving from the Arab countries to the western countries (refugee crises) and Russia’s takeover of Crimea. Furthermore, the latest vote of the United Kingdom’s departure from the European Union, or “Brexit,” raises the level of uncertainty about the future economic policies and the Euro.

(Baker et al., 2016) formulated an EPU index, using the frequency count of newspaper articles. The Kommersant, a nationwide disseminated daily newspaper mainly focused on politics and economics. This prevalence of computation by the total amount of the articles counted in the same newspaper and same month. Our variables comprise the Russian language tantamount of tax, the central bank, law, expenditures, and policy, and political-institutional terms like budget, Duma, and others. To capture for the important historical event in Russia, like Russia's financial crises, Credit Crunch, Ukraine and Chechnya war, Baker at el constructed some indicators using the daily prevalence computation of newspaper articles in the same month.

The Russian index reacts to political development in Ukraine, Russian military conflicts, the 1998 Russian financial crisis, the “taper tantrum” of 2013 bring about by an anticipated change in US monetary and policy, the collapse of the Lehman Brothers, and other developments. Although the index of Russia is boisterous, manifesting our credence on a single paper, it spectacle that our approach results in vital information even for nations with a high level of regulations on freedom of the press (Baker et al., 2016).

The global natural gas consumption has experienced a rapid increase over the last twenty-one years, the global natural gas consumption in 2018 has amounted to about 3.8 trillion cubic meters (*IEA – International Energy Agency*, n.d.). The global natural gas consumption would increase from 120 trillion cubic feet to 203 trillion cubic feet from 2012 to 2040; natural gas is the largest source of primary energy and is a source for fuel for industrial and electric sectors (IEA – International Energy Agency, n.d.).

Natural gas market lacks a uniform global pricing, unlike the crude oil market. Nevertheless, the current liberazation of gas market and the advancement in liquidized natural gas (LPG) market make the gas market approaching a common market. There are different types of natural gas pricing globally due to the disintegration of the gas market. Therefore, different price mechanism is adopted by different part of the world (Shi et al., 2019; Outlook, 2017). Oil linkages and oil indexation are the two major oil pricing applied for international trade of gas. According to (Outlook, 2017) the oil indexation was replenished by hub prices in the Northeast Europe, United Kingdom and United States for three decades (1980s, 1990s and 2010s respectively).

Russia is the 2rd natural gas producer in the world. In 2017, Russia's natural gas production was 755.8 billion cubic meters. The natural gas sector is the major source of revenue to Russia; the Russian government budget and policies rely heavenly on the exportation of natural gas; Russia is the largest natural gas exporter in the world. (*BP* Statistical Review *of World Energy 2017*, n.d.). According to the index Mundi Russia natural gas consumption increase from 420.65 billion cubic meters in 2017 to 431.10 billion cubic meters in 2018, Russia is the 4th natural gas-consuming country in the world. Russian natural gas proven reserve is about 47.57 cubic meters, Russia owns almost one-fourth of the world's proven natural gas reserves (World Factbook, 2018).

The recent development in the global energy sector have significantly increased the production and consumption of natural gas, this is as a result of advancement in modern technology in the sector. These changes lowered natural gas prices globally. Natural gas is among the commodities that heavenly contributes to the economic growth of Russia, the economic policies made by the government is what shape the economy of the country. This is what motivated us to Study the interconnection between Russia EPU index and energy prices.

Concentrating on both volatility and price fluctuation in the natural gas market. I also accentuate the interconnections among EPU and price of natural gas. However, natural gas consumption and economic growth nexus got a lot of attention by researchers, to the best of my knowledge no research has specifically examine the relationship between EPU and natural gas price. Select Russia as our case study based on the global importance of Russia in natural gas production (755.8 billion cubic meters), consumption (431.10 billion cubic meters), and proven reserves (47.57 cubic meters).

The aim of this chapter is to provide answers to the questions below:

(1). How the volatility of EPU index influence the volatility of natural gas prices in Russia?

(2). what is the interconnection between EPU and natural gas price in Russia?

I, therefore, make use of the EPU index formulated by (Baker et al., 2016) from January 1990 to December 2019, I also employed monthly data of the natural gas price. I further make use of the both the univariate and multivariate GARCH models for my analysis. The univariate GARCH models are used to examine the volatility characteristics of the variables while the multivariate models are employed to evaluate the dynamic linkages and correlations among the variables; we additionally employ the Multivariate Generalized Autoregressive Conditional Heteroscedasticity (MGARCH) to examine the volatility spillovers among our variables of interest.

The major findings of this chapter indicates that some major world events like 2008/09 world recession, 9/11 terrorist attack, Russian financial crisis and the

Russia invasion of Crimea have an influence on the relationship between EPU index and energy prices.

The remaining of this chapter is organized as follows. Section two is highlight of the previous studies, section three discuss methodology and explanations of the data. Section four presents the discussions of the outcomes, the conclusion is at the last section.

2.2 Literature Review

EPU is the probability that the subsequent time policies will be different from the present policies and the effect of these variations on microeconomics and macroeconomics activities (Baker et al., 2016). (Bloom, 2009) reignited the impacts of macroeconomics on uncertainty. Further Alexopoulos and (Alexopoulos & Cohen, 2009; Baker et al., 2014; Castelnuovo et al., 2013; Leduc & Liu, n.d.; Nodari, 2014), are the most recent studies that also investigates the impacts of macroeconomics on economic policy uncertainty in the USA. Such studies have focus on within the USA, that is, they pay attention to the macroeconomic variable that is affected by EPU. In similar studies, a negative relationship exists between economic policy uncertainty and stock market return in China (Arouri & Roubaud, 2016; Chang et al., 2015; Chen et al., 2019; Jiang et al., 2019). EPU harms consumers, investors, and corporations, as an expansion of EPU distract the consumption behavior of consumers and decrease the investment pattern of investors and corporations (Converse, 2018; Handley & Limao, 2015; Rodrik, 1991).

In other studies, it is recorded that EPU is positively related to high stock volatility and negatively related to the return on the stock market (Arouri & Roubaud, 2016;

Chang et al., 2015; You et al., 2017). Economic policy uncertainty and oil price are extensively studied in the literature, (Kang et al., 2017) investigates the effect of EPU and oil price on stock return, a case study of oil and gas firms and record a negative effect of EPU shock on stock return, and a positive shock of oil price on stock return. In a similar study (Aloui et al., 2016), A positive interaction among EPU and crude oil price amid the period of high financial activities. (Reboredo & Uddin, 2016) report no significant causal relationship between oil price and EPU. In the US economy, high economic policy uncertainty increases the shocks in the oil price (Kang et al., 2017). In a similar study, it is discovered that EPU and financial uncertainty in the US does not always affect oil price, it depends on the time (Degiannakis et al., 2018). Using the quantile-on-quantile model (Han et al., 2019) examine state-dependent spillover impacts of policy uncertainty on the currency in the US and report a significant relationship.

The interaction among economic growth and energy consumption was initially examined by the following studies among others (Akarca & Long, 1980; Kraft & Kraft, 1978; Proops, 1984). Conflicting outcomes have been recorded by these studies, the conflictions led to the formation of four hypotheses. “Growth hypotheses” (energy consumption led to economic growth), “neutrality hypotheses” (no relationship) “conservation hypotheses” (economic growth led to energy consumption) “feedback hypotheses” (energy consumption and growth influences each other).

(Işik, 2010) discovered a positive interconnection Between GDP and gas consumption a case study of Turkey. In another study, (Lim & Yoo, 2012) report a feedback relation among natural gas consumption and economic growth in Korea.

The presence of a feedback relationship is recorded by (Solarin & Shahbaz, 2015) in their study of the relationship between natural gas consumption, FDI, trade openness, gross capital formation and GDP. In another study, (Rafindadi & Ozturk, 2015) applied ARDL and Johansen cointegration models in their study of the natural gas consumption and GDP growth nexus in Malaysia, the findings of the research report that economic growth is not an important predictor of natural gas consumption.

Natural gas consumption is positively related to the economic growth of the GCC countries, in the long run, furthermore, a bidirectional causal relation exists among GDP and natural gas consumption (Ozturk & Al-Mulali, 2015). In a similar study, a feedback relationship is found between natural gas consumption and economic growth in OPEC member countries (Solarin & Ozturk, 2016). (Hassan et al., 2018) investigate the interconnection among natural gas consumption and GDP in Pakistan, the outcome of the research documents that natural gas consumption is a significant predictor of economic growth. The study of (Sinaga, 2019) recorded a unidirectional causality moving from gas consumption to GDP in Malaysia.

Natural gas consumption does not improve GDP in the short-run, but natural gas consumption increases economic growth in the long-run in 12 European countries included in the study (Fadiran et al., 2019). (Akadiri et al., 2019) discovered that natural gas consumption is an important predictor of GDP in Saudi Arabia, they further report a non-causal relationship between natural gas consumption and total trade, and the same relation is discovered for GDP and total trade. (Erdoğan et al., 2019), study the relationship among GDP and natural gas consumption in Turkey is examined from 1983 through 2017. The outcome reveals no causal interconnection among the variables of interest for the whole period of the study, however. The study further applied causality estimations for sub-period, a one-sided causality is discovered from natural gas consumption to GDP from 2001 to 2015, 1997-2011 and 1996-2010, and a unidirectional causality running from economic growth to natural gas from 2000 to 2014 (Erdoğan et al., 2019).

It is predicted that the volume of natural gas that will be consumed by the residents, commerce, and industries in the United States of America will slightly decrease between 2019 and 2025, the research further predict a slow growth of natural gas consumption (average of 1.2%), and a significant improvement of natural gas consumption in the power generation sector to about 39% in the year 2025 (W. Liu et al., 2020).

Previous studies recorded that uncertainty played a significant role in determining oil price changes. According to (Van Robays, 2016), price volatility which is caused by fundamentals; then, uncertainty intensifies the price effect of demand and supply shocks. According to (Litzenberger & Rabinowitz, 1995) uncertainty determines the decisions of oil producer, which directly affect the oil price. The novel study of (Hu et al., 2018) was the first research to model prudent demand depends on uncertainty changes. The findings of the research indicate that crude oil market is significantly affected by the increase in prudent demand for oil which is caused by high level of uncertainty. (Hailemariam et al., 2019) Investigate the interconnection between oil prices and EPU in G7 nations. The findings of the study revealed the impact of oil prices on economic policy uncertainty is time-varying. (Lin et al., 2022) Examine the relationship between oil prices and economic policy uncertainty for a panel of global oil importers and exporters. The findings of the study report that oil prices respond negative to economic policy uncertainty. (Chen et al., 2019) documents that oil price shocks have a positive impact on EPU, while the effect of economic policy uncertainty on oil price is time-varying.

The demand and supply of natural gas, the price of crude oil and climatic factors are the major factors that affect the natural gas prices (Brown & Yucel, 2008; Caporin & Fontini, 2017; Ramberg & Parsons, 2012). (T. Wang et al., 2020), report that crude oil price is the major determinant of natural gas price in China. (Olanipekun et al., 2019) discovered a positive and negative asymmetric relationship between EPU and gasoline price for a group of 18 selected nations for the period of 1998-2017. (Scarcioffolo & Etienne, 2021) discovered EPU increases volatility in both oil and gas markets in the United States. (Dash & Maitra, 2021) investigate linear and non-linear causality among energy prices and EPU. The study discovered a negative relationship between energy prices and EPU.

This chapter broadens the previous studies on the dynamics linkages between EPU and the energy prices. Russian economy heavily relies on natural gas, crude oil, and hydrocarbons, about one-third of the government revenue is generated from natural gas, crude oil, and hydrocarbons, and Russia is the second-largest producer of natural gas in the world and has the highest natural gas proven reserves (Energy Information Administration 2018, n.d.). Numerous sectors in the economy can be affected by the adjustments in the natural gas market, afterward poignant the economic policy in Russia. Considering the significance of EPU on the consumption and production of natural gas, we therefore, anticipate the natural gas price to be affected by EPU.

2.3 Methodology

Oil prices, gas prices, and EPU are among the most volatile economic series. In this chapter, we are going to employ both the univariate and multivariate GARCH models for our analysis. The univariate GARCH models are used to examine the volatility characteristics of the variables while the multivariate models are employed to evaluate the dynamic linkages and correlations among the variables. Meanwhile, the majority of commodity prices including oil price and gas prices are often not stationary (means and variances are not constant), which is contrary to the traditional statistical assumptions of the volatility models. Therefore, in line to (Antonakakis et al., 2014), I employ Augmented Dickey-Fuller(ADF) and Philips-Perron (PP) unit root test and generated the returns of natural gas, oil prices and the EPU index which are integrated at order zero (stationary at level). Additional characteristics of commodities prices are time-changing volatility clustering, which we considered by employing the univariate and multivariate Generalized Autoregressive Conditional Heteroscedasticity GARCH techniques starting with the ARCH-LM test.

2.3.1 Univariate GARCH Models

Specifically, I used GARCH, EGARCH to examine the volatility of the variables of interest in this study. (Bollerslev 1986) developed the GARCH model with the mean and variance equations specified as follows in (1) and (2) respectively.

$$R_t = \alpha_0 + \sum_{i=1}^{p} \gamma_i R_{t-i} + \varepsilon_t \tag{1}$$

$$\theta_t^2 = \delta_0 + \sum_{i=1}^{p} \lambda_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \gamma_i \theta_{t-j}^2 \tag{2}$$

In this study, R_t represents the EPU and energy prices, θ_t^2 is conditional variance, $\sum_{i=1}^{p} \lambda_i \varepsilon_{t-i}^2$ and $\sum_{j=1}^{q} \gamma_i \theta_{t-j}^2$ are the ARCH and GARCH terms respectively. For a stationary series, $0 < \sum_{i=1}^{p} \lambda_i + \sum_{j=1}^{q} \gamma_i < 1$. When $\sum_{i=1}^{p} \lambda_i + \sum_{j=1}^{q} \gamma_i \longrightarrow 1$, the series is slow-mean reverting while $\sum_{i=1}^{p}\lambda_i + \sum_{j=1}^{q}\gamma_i \longrightarrow 0$ implies that the series is fast mean-reverting.

Also, considered in this chapter are the EGARCH models built by (Nelson, 1991) to account for asymmetric and leverage effect not captured by the GARCH model. This model factored in the possibility of the difference in the effect of positive and negative shock on the series. While the mean equation remained as equation (1), we specified the variance equation of the EGARCH model in equation (3).

$$\ln(\theta_t^2) = \delta_0 + \delta_1 \frac{|\varepsilon_{t-i}|}{\sqrt{\theta_{t-i}^2}} + \varphi \frac{\varepsilon_{t-i}}{\sqrt{\theta_{t-i}^2}} + \emptyset ln(\theta_{t-1}^2) \qquad (3)$$

The asymmetric effect is captured by the φ. In the presence of an asymmetric effect, $\varphi > 0$ implies that the effect of positive shock is greater than the effect of negative shock of the same magnitude. On the other hand, $\varphi < 0$ implies that the effect of negative shock is greater than the effect of positive shock of equal magnitude. If $\varphi = 0$, there is no asymmetry in the effect. That is, the effect of positive shock (good news) is the same as the effect of negative shock (bad news) of equal size. Examining the symmetric effect is relevant in this chapter because of the information-centric nature of EPU and energy prices.

2.3.2 Multivariate GARCH (MGARCH) Techniques

Several multivariate GARCH (MGARCH) models were developed 2.3.2 for the examination of the co-movement among different variables of interest in finance and economics. For example, (Bollerslev, 1990) suggested the steady conditional correlation technique to form time-invariant conditional correlation matrix. The major defect of the CCC approach is the expectation of steady conditional correlation for a given period, which is unrealistic for empirical application (Engle, 2002; Tse & Tsui, 2002). Thus, in separate and independent studies generalized the

CCC model to the Dynamic Conditional Correlation GARCH (DCC-GARCH) technique. The DCC-GARCH technique is outperforms all other variants of the GARCH-based models because it measures time-varying effects, consistent with lower volatility in the conditional volatility of the variables considered, and provide more accurate conditional variances (Ali et al., 2021; Botshekan et al., 2021; Engle, 2002; Ghosh et al., 2022; Hung, 2021; Nguyen et al., 2022; Tse & Tsui, 2002). It also provides insights on the synchronization and volatility clustering in the commodity markets (Afzal et al., 2021).

Thus, to examine the time-varying volatilities and dynamic linkages between Russian EPU and the energy prices (oil and natural gas prices); we employ the Dynamic Conditional Correlation (DCC) in this study.

Supposed we have the returns, $\boldsymbol{r_t}$ of energy prices and Russian EPU with expected value zero and covariance matrix $\boldsymbol{H_t}$. We define the (Engle, 2002) version of the DCC-GARCH model as follows.

$$\begin{cases} \boldsymbol{y_t} = \boldsymbol{\mu_t} + \boldsymbol{r_t} \\ \boldsymbol{r_t} = \sqrt{\boldsymbol{H_t}}\boldsymbol{\varepsilon_t} \\ \boldsymbol{H_t} = \boldsymbol{D}_t\boldsymbol{R}_t\boldsymbol{D}_t \\ \boldsymbol{D}_t = diag\left(\sqrt{\boldsymbol{h_{11t}}} \ldots\ldots \sqrt{\boldsymbol{h_{nnt}}}\right) = \begin{bmatrix} h_{11,t} & 0 & 0 \\ 0 & h_{22,t} & 0 \\ 0 & 0 & h_{33,t} \end{bmatrix} \\ \boldsymbol{R_t} = \{diag(Q_t)^{-0.5}\}\, \boldsymbol{Q}_t\{diag(Q_t)^{-0.5}\} \end{cases} \quad (4)$$

Where $\boldsymbol{H_t}$ is the conditional variance matrix, $\boldsymbol{\mu}_t$ symbolized a vector of expected values of $\boldsymbol{y}_t$, $\boldsymbol{D}_t$ represents a matrix of non-constant standard deviation, ε_t is a vector of error terms with zero expected value $E(\boldsymbol{\varepsilon}_t) = 0$ and constant variance, $E(\boldsymbol{\varepsilon_t}\, \boldsymbol{\varepsilon_t'}) = I$ while $\boldsymbol{Q}_t = (q_{ijt})$ representing $n \times n$ symmetric positive definite matrices (Engle, 2002). Three variables (EPU, natural gas price and crude oil price). Thus, $(n \times n) = (3 \times 3)$ matrix.

$$\boldsymbol{Q}_t = (1 - \alpha - \beta)\overline{\boldsymbol{Q}}_t + \alpha \boldsymbol{u}_{t-1}\boldsymbol{u}'_{t-1} + \beta Q_{t-1}, \qquad \alpha, \beta > 0 \tag{5}$$

The parameters a and b are nonnegative scalar parameters. The model is mean-reverting if $\alpha + \beta < 1$ and integrated if $\alpha + \beta = 1$. The Q_t stands for the unconditional variance between variable i and j, $\overline{\boldsymbol{Q}}$ is the unconditional covariance matrix of u_t, and $\boldsymbol{u}_{t-1}\boldsymbol{u}'_{t-1}$ denotes that lagged function of the standardized residuals.

The conditional covariance is given as

$$h_{ij,t} = \frac{q_{ij,t}\sqrt{h_{ii,t}}\sqrt{h_{jj,t}}}{\sqrt{q_{ii,t}}\sqrt{q_{jj,t}}} \tag{6}$$

Where $h_{ii,t} = \omega_t + \gamma_i \epsilon_{t-1}^2 + \lambda_i h_{ii,t-1}, i = 1, \ldots \ldots n$. For the asymmetric version,

$$\boldsymbol{Q}_t = (1 - \alpha - \beta)\overline{\boldsymbol{Q}}_t - g\overline{N} + \alpha \boldsymbol{u}_{t-1}\boldsymbol{u}'_{t-1} + \beta Q_{t-1} + g\boldsymbol{n}_{t-1}\boldsymbol{n}'_{t-1}, \tag{7}$$

Where, $\alpha + \beta + \delta g < 1$ δ is the maximum eigenvalue$[\bar{Q}^{-0.5}\,\overline{N}\bar{Q}^{-0.5}]$, $\overline{N} = \frac{1}{T}\sum_{t=1}^{T} g\boldsymbol{n}_t\boldsymbol{n}'_t$, $\boldsymbol{n}_t = I[\boldsymbol{u}_t < 0] \circ \boldsymbol{u}_t, I[.]\ is\ k \times 1$ indicator function that assumes value 1 if the argument is true and zeroes otherwise and '∘' symbolizes the element-wise operator.

The scalar parameters (a and b) account for the effects of the innovation (past shocks) and past dynamic conditional correlations on current dynamic conditional correlations (Qian & Diaz, 2017).

To ensure robustness, I also employed the corrected Dynamic Conditional Correlation (cDCC) introduced by (Aielli, 2008) and improved by (Aielli, 2013). The specification of the corrected cDCC-GARCH model is the same as that of the

DCC-GARCH model. However, (Aielli, 2013) identified that the DCC is asymptotically biased in the estimation of the sample covariance matrix and modified the model accordingly. Thus, this study used both the DCC and cDCC techniques to analyze the time-changing conditional interaction between economic policy uncertainty, natural gas prices, and oil prices.

2.3.3 Data

The EPU index for Russia is formulated by (Baker et al., 2016) using the frequency count of newspaper articles, the Kommersant, a nationwide disseminated daily newspaper mainly focused on politics and economics. This prevalence of computation by the total amount of the articles counted in the same newspaper and the same month (Baker et al., 2016). The current chapter employed monthly EPU index the time spans from January 1990 to December 2019. EPU index is available at the EPU website (http://www.policyuncertainty.com/). We obtained the data on the natural gas price and crude oil price from the British Petroleum (BP) Statistical Review of the World Energy.

2.5 Empirical Results

Table 1 contains the summarized statistical information about all the three variables and their returns series. The average monthly natural gas spot price (NGPRICE) about four US Dollars per million British thermal units while the average WTI crude oil spot price (OILPRICE) is approximately 52 US Dollars per barrel. The average Russian economic policy uncertainty index (REPU) is about 134, which is above the normalized value (100) of the index ascribed to 1997 considered as a relatively low uncertainty period (Davis, 2016). The minimum value of the NGPRICE, OILPRICE, and REPU are 1.43, 11.35, and 12.399 while the maximum values are 13.45, 133.88, and 431.25 respectively. The wide range between the minimum values implies significant fluctuations in all the series over the period. The large standard deviations of the level series particularly for OILPRICE and REPU also indicate volatilities. The standard deviation shows that the REPU is the most volatile followed by the OILPRICE. Regarding the symmetry and tail behavior of the series, all the level variables are skewed to the right (positive skewness or longer right tail than left tail) while the kurtosis shows that NGPRICE, REPU, and all the return series are heavy-tailed (kurtosis greater than 3) while OILPRICE is light-tailed (kurtosis less than 3). Thus, the skewness and kurtosis revealed the variables considered in the current chapter are not normally distributed. The Jarque-Bera test statistics, which are significant for all the variables, equally indicate the rejection of the normality of the distributions of the series. The distribution of the series is important for the estimation of the volatility models. Therefore, we estimated all the univariate and multivariate GARCH with the student-t distribution instead of the Gaussian (normal) error distribution. We also conducted the ARCH LM, Q-statistics, and Q-squared tests for volatility. All the statistics indicate the presence of volatility effects in all the variables. This implies that the appropriate methodology for the estimation of the models in this study is the volatility models. The correlation coefficients for all pairs of the variables are less than 0.5, indicating the absence of a multicollinearity problem.

Table 1: Descriptive statistics

Statistics	ngprice	oilprice	repu	rngprice	roilprice	Retrepu
Mean	4.0651	51.816	133.63	-8.8600	0.00443	-0.0019
Median	3.3320	48.475	109.46	-0.0039	0.01487	0.0003
Maximum	13.454	133.88	431.24	0.4063	0.21386	1.7525
Minimum	1.4260	11.350	12.398	-0.3956	-0.33198	-2.0855
Std. Dev.	2.2182	29.299	85.641	0.1189	0.08298	0.6408
Skewness	1.5964	0.5154	0.9904	0.0587	-0.72749	-0.2301
Kurtosis	5.9530	2.2183	3.5609	3.7271	4.45875	3.4243
Jarque-Bera	245.88	21.753	55.091	7.05113	55.1826	5.0962

Probability	0.0000	0.0000	0.0000	0.02943	0.00000	0.0782
Observation	312	312	312	312	312	312
ARCH test F-stat	19.8418 [0.000]	106.514 [0.000]	19.4048 [0.000]	3.564416 [0.0295]	16.54563 [0.0001]	6.9004 [0.009]
Q-stat (5)	11.249 [0.047]	58.995 [0.000]	25.186 [0.000]	13.952 [0.016]	20.417 [0.001]	39.746 [0.000]
Q-stat (10)	33.085 [0.000]	79.183 [0.000]	44.175 [0.000]	39.372 [0.000]	27.316 [0.002]	45.093 [0.000]
Q-square stat (5)	54.203 [0.000]	162.03 [0.000]	11.385 [0.044]	5.8527 [0.321]	62.934 [0.000]	16.442 [0.006]
Q-square stat(10)	62.140 [0.000]	183.07 [0.000]	35.492 [0.000]	16.965 [0.075]	71.956 [0.000]	28.048 [0.002]
Correlation						
Variables	repu	oilprice	ngprice	retrepu	rngprice	roilprice
repu	1.00000					
oilprice	0.18429	1.00000				
ngprice	-0.2217	0.42697	1.0000			
retrepu	0.36607	0.01975	0.0194	1.00000		
rngprice	-0.0016	-0.0073	0.1277	0.07165	1.00000	
roilprice	-0.0633	0.03671	0.0176	0.01456	0.22716	1.0000

REPU=Russian economic policy uncertainty index, NGPRICE= Hub Natural Gas Spot Price (Dollars per Million British thermal units-Btu), OILPRICE= WTI crude oil spot price. RETREPU, RNGPRICE, and ROILPRICE are the returns of the three variables respectively. [ ] denotes P-values

2.5.1 Dynamics of the Monthly REPU and Energy Prices and their Returns

The graphical illustration (shown in Figure 1) displays the dynamics of the REPU, energy prices, and their returns over the period 1994-2019 considered in this study. The time series graphs show that all the variables have a trend and fluctuate over the period. In the case of the REPU, the trend and changes reflect major economic and political events in Russia. For instance, the high values of the index between 1995 and 1996 reflect the first Chechen war, fought between December 1994 and August 1996. The period also witnesses the Russian interbank credit crisis and low natural gas prices. Moreover, REPU continuously rises from 2014 to 2019. In addition to the Russo-Ukrainian war, which resulted in western sanctions on Russia, on the average, the natural gas and crude oil prices consistently fall during the period

(2014-2019). This somewhat indicates the simultaneous movement of the three series. Thus, there is seemingly interdependence in the dynamics of the variables. The graph shows that the returns of the series are mean reverting and exhibit the presence of volatility clustering. The volatility of the REPU is the highest followed by the OILPRICE volatility. The volatilities are, however, concurrently moves in clusters during the period. The periods of low volatility follow periods of high volatility in all the series. This signals the interference of the volatilities of the variables, which we examined in this chapter.

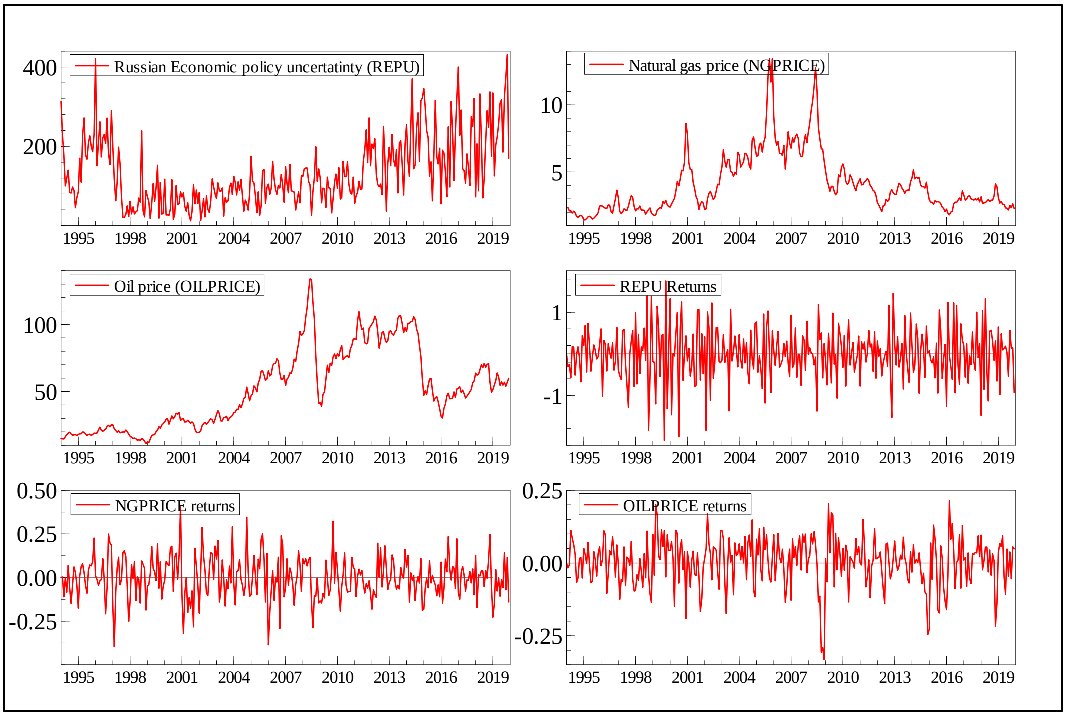


Figure 1: Dynamics of the monthly REPU uncertainty and energy prices and their returns

Table 2: Outcome of stationarity tests

Philips Perron (PP) Test						
	I(0)			I(1)		
Variables	Constant only	Constant and trend	None	Constant only	Constant and trend	None

Ngprice	-2.83***	-2.7921	-1.2607	-15.21**	-15.21**	-15.24**
Oilprice	-1.7037	-2.1123	-0.3741	-11.84**	-11.82**	-11.85**
Repu	-10.65**	-11.98**	-3.789**	-57.93**	-64.17**	-58.08**
Retrepu	-64.69**	-74.45**	-64.95**	-273.7**	-289.7**	-275.5**
Rngprice	-14.76**	-14.77**	-14.79**	-218.5**	-228.7**	-208.8**
Roilprice	-13.48**	-13.48**	-13.48**	-110.0**	-109.7**	-110.4**

Augmented Dickey-Fuller (ADF) test.

	I(0)			I(1)		
Variables	Constant only	Constant and trend	None	Constant only	Constant and trend	None
Ngprice	-3.016**	-2.9825	-1.4242	-15.21**	-15.19**	-15.24**
Oilprice	-2.3086	-2.7655	-0.797	-11.96**	-11.95**	-11.97**
Repu	-3.165**	-4.128**	-1.2093	-16.86**	-16.86**	-16.89**
Retrepu	-13.33**	-13.33**	-13.36**	-10.90**	-10.89**	-10.92**
Rngprice	-14.93**	-14.93**	-14.96**	-14.59**	-14.57**	-14.61**
Roilprice	-13.53**	-13.54**	-13.52**	-14.03**	-14.00**	-14.05**

repu=Russian economic policy uncertainty index, ngprice= Hub Natural Gas Spot Price (Dollars per Million British thermal units-Btu), oilprice= WTI crude oil spot price. retrepu, rngprice, and roilprice are the returns of the three variables respectively while *, **, and *** denote 1%, 5%, and 10% levels of significance respectively.

2.5.2 Stationarity (Unit root) Test Results

Time series are often non-stationary and have a trend. As such, the regression estimates of a non-stationary variable on another non-stationary variable(s) are spurious and results in an invalid conclusion. Therefore, it is imperative to examine the stationarity property of the variables before proceeding to the estimations of the regression models. Moreover, the stationarity of the variables is an underlying assumption of the GARCH models. Hence, we conducted Augmented Dickey-Fuller (ADF) and Philips Perron (PP) unit root tests. Table 2 contains the results of the unit root test. The results of both ADF and PP indicate that, at 5% level of significance, the level series of oil price (OILPRICE) and natural gas price (NGPRICE) are not stationary while the Russian economic policy uncertainty index is stationary at levels in all cases (Constant only, constant and trend, and none). However, the return series of energy prices and EPU are integrated of order zero in both ADF and PP tests. Since some of the level series are not stationary at levels, we used the return series for the estimation of the volatility models throughout this study.

2.5.3 Estimates of Univariate Models

We first estimated the symmetric and asymmetric univariate ARMA-GARCH (1, 1) models to evaluate the volatility characteristics of the variables and identify the best strategy for the analysis multivariate models. The symmetric and asymmetric GACH models employed are GARCH (1, 1) and exponential GARCH (1, 1) models EGARCH (1, 1) respectively. These models are identified to be the best for the modelling of stationary volatile series (Engle, 2002; Nelson, 1991). Table 3 displays the results of the univariate volatility models. The results show that ARMA terms are statistically significant for the RETREPU models but insignificant for the RNGPRICE and ROILPRICE models. Moreover, the coefficients of the ARCH and GARCH terms are significant for all the symmetric models. This confirms the presence of the ARCH and GARCH effects in all the variables. The sum of the ARCH and GARCH terms is less than one in each model. This shows that the variables are mean-reverting. Meaning, the effect of shocks on the returns of all variables is temporary. Russia has a significant role in energy markets, when there is a shock on the variables; the results indicate that oil price reverts to its mean faster than EPU and natural gas prices. This reflects the fact that Russia is the biggest exporter and the 2rd biggest producer of the natural gas globally (IEA, 2019).

Hence, when there is a shock, for instance, on the natural gas supply in Russia, the effect on the price lasts longer than the effect of a similar shock on crude oil supply. Even, the RETREPU recovers from shock faster than the natural gas price.

Considering the estimates of the asymmetric models, the variables still exhibit slow-mean reverting, and the asymmetric term is statistically significant for all the variables. The estimates indicate that the coefficients of the models for RETREPU and RNGPRICE are positive. This implies the effect of positive shock is greater than the effect of negative shock of the same magnitude. For example, improvement in the supply of natural gas has more influence on natural gas price than when the supply is reduced. (Abdulkareem & Abdulkareem, 2016; Alberini et al., 2019; Krichene, 2002; Liddle et al., 2020; Rajabi & Mousavi, 2019). Reduction in the supply of natural gas does not always move with the demand. At best, demand adjusts with less than the magnitude of the increase in supply. On the other hand, a rise in supply creates a surplus, which results to a fall in the prices and an increase in demand. Natural gas demanders buy more and reserve for subsequent use.

Conversely, the parameter estimate of the asymmetric term for the OILPRICE model is negative and highly significant. This implies that the effect of negative shock on the crude oil price is greater than the effect of positive shock of equal magnitude. That is, for instance, a supply cut in crude oil price affects the price more than the supply increase of the same quantity.

The post-estimation ARCH test statistics (F-statistics and nR2) are statistically insignificant for all the models. This shows that all the models capture the ARCH effect and their estimates are statistically valid for policy analysis. We use the

Schwarz information criterion (SIC) to choose the best models. The SIC values of the EGARCH models are smaller than their SIC values of the GARCH models for all the variables. Thus, the symmetric models outperformed the symmetric models in this study. This conforms to the findings of (Abdulkareem & Abdulkareem, 2016). Hence, in the subsequent estimations, we consider the results of the asymmetric models superior to their symmetric counterparts.

Table 3: estimates of univarate GARCH models

Variables	RETREPU		RNGPRICE		ROILPRICE	
	GARCH (1 1)	EGARH (1 1)	GARCH (1 1)	EGARH (1 1)	GARCH (1 1)	EGARH (1 1)
Mean equation	(1)	(2)	(3)	(4)	(5)	(6)
Constant	0.0037*	0.0054*	0.00012	0.000229	0.008146	0.00423
	(0.0050)	(10.2770)	(0.0086)	(0.0075)	(0.00544)	(0.0059)
AR(1)	0.2289 *	0.8885**	-0.10018	0.030043	0.117236	0.15284
	(0.0717)	(0.02823)	(0.3932)	(0.2959)	(0.40183)	(0.2122)
MA(1)	-0.893*	-0.5254*	0.29227	0.15701	0.046553	0.07988
	(0.0308)	(0.06055)	(0.3525)	(0.2880)	(0.40673)	(0.2169)
Variance equation						
Constant	20.7649	0.27447*	0.001**	-0.16243	0.001234	-5.4510
	(24.185)	(0.03647)	(0.0002)	(0.0972)	(0.00085)	(0.9389)
ARCH (1)	0.0683*	-0.083**	0.049**	0.097178	0.1386**	0.03445
	(0.0245)	(0.04205)	(0.0206)	(0.0206)	(0.06469)	(0.1439)
GARCH (1)	0.9316*	0.97447*	0.9299*	0.966*	0.667*	-0.05**
	(0.0236)	(1.7500)	(0.0196)	(0.0196)	(0.17743)	(0.1871)
Asymmetry (1)		0.12718*		0.0809**		-0.36**
		(0.02192)		(0.0365)		(0.0987)

Diagnostic test						
SIC	1.62959	1.616514	-1.18789	-1.36712	-2.14659	-2.1496
ARCH Test						
F-statistics	0.22335	0.010984	0.00830	0.006366	0.283098	1.02442
	[0.6368]	[0.9166]	[0.9275]	[0.9365]	[0.5951]	[0.3123]
nR^2	0.22464	0.011054	0.00836	0.006408	0.284675	1.02766
	[0.6355]	[0.9163]	[0.9272]	[0.9362]	[0.5937]	[0.3107]

P-values are in square brackets, [ ] while *, ** and *** denote 1%, 5% and 10% levels of significance respectively.

2.5.5 Results of Multivariate Models

Table 4 reports the parameter estimates of the DCC-MGARCH and the cDCC-MGARCH models. The results indicate that the coefficients of Alfa (α) and Beta (β) are statistically significant in all the models, indicating a dynamic (not constant) conditional correlation between the Russian EPU and energy prices (natural gas and crude oil prices). The rejection of the hypothesis of the constant conditional correlation implies dependency among the variables. Therefore, there is an interconnection (co-movement) between each pair of the energy prices and EPU. Moreover, the sum of the MGARCH parameters is less than one ($\alpha + \beta < 1$) for all the models, implying that the conditional correlations are mean-reverting. Thus, the DCC-MGARCH models are justifiably adequate in capturing the time-varying conditional correlations between the variables. Comparing the models, the Log-likelihood values of the cDCC models are less than the Log-likelihood of the DCC models, indicating that the cDCC outperforms the DCC models. Also, the Log-likelihood of the asymmetric cDCC model is the smallest. Hence, it is the best model.

Table 4: Parameter estimates of MGARCH models

	Symmetric model [GARCH]		Asymmetric model [EGARCH]	
Variables	DCC model	cDCC model	DCC model	cDCC model
RETREPU vs RNGPRICE	0.1189**	0.1178**	0.1226*	0.12048*
	[0.0468]	[0.0464]	[0.0613]	[0.0608]
RETREPU vs OILPRICE	0.0098	0.011240	0.0067	0.009536
	[0.8768]	[0.8569]	[0.9234]	[0.8903]
OILPRICE vs RNGPRICE	0.2833***	0.2829***	0.3148***	0.3136***
	[0.0001]	[0.0000]	[0.0000]	[0.0000]
Alfa (α)	0.0470***	0.04603*	0.0720**	0.0749**
	[0.0002]	[0.0527]	[0.0281]	[0.0331]
Beta (β)	0.6008***	0.5726***	0.6236***	0.5966***
	[0.0001]	[0.0013]	[0.0000]	[0.0000]
Log-likelihood	357.135	357.057	306.769	306.755

P-values are in square brackets, [ ] while *, ** and *** denote 10%, 5% and 1% levels of significance respectively.

The log-likelihood shows that the asymmetric model (cDCC-EGARCH) is the best. As a result, we used the estimates of the asymmetric cDCC (EGARCH-DCC) model to examine the conditional correlations, variances, and covariance of the Russian EPU, natural gas price, and crude oil price. Figure 2 depicts the conditional correlations between the Russian EPU index, natural gas price, and crude oil price. The figure shows that the conditional correlations between the variables are dynamic (time-varying). Meaning, the conditional correlation sometimes declines sharply and sometimes increases sharply. It alternates between high and low values. For example, the conditional correlation between gas price and economic policy uncertainty dropped significantly around 1998, 2016, and 2019. These years coincide with the period of the Russian financial crisis, the western sanctions against Russia for the Russo-Ukrainian war, and the onset of the coronavirus (COVID-19) pandemic respectively. Similarly, the correlation between crude oil price and EPU declined hugely during the 2008-2009 global financial crisis and increase during the oil boom period in 2012. Moreover, the conditional correlation between the oil price and the natural gas price dropped sharply in 2001 and 2019. These years indicate two significant global events, the September 11, 2001, terrorist attack, and the onset of the COVID-19 pandemic in 2019. This indicates that, as global commodity prices, the correlation between energy prices are associated with global events. The conditional correlations increase in the years preceding the decrease in the correlations. Furthermore, the correlation between the oil price and natural gas price is the highest followed by the correlation between natural gas price and economic policy uncertainty. The correlation between crude oil prices and economic policy uncertainty is the lowest. This demonstrates the importance of natural gas to the Russian economic policy agenda. Russia has been the highest exporter of and second-largest producer, it is plausible that it correlates policy uncertainty more than the crude oil price does. Albeit, Russia has a significant role in the crude oil market, the EPU co-movement is greater with gas price that the crude oil price. We further noted that the correlation among EPU and gas price and that of between EPU and oil price follows the same patterns. Both move at the same time.

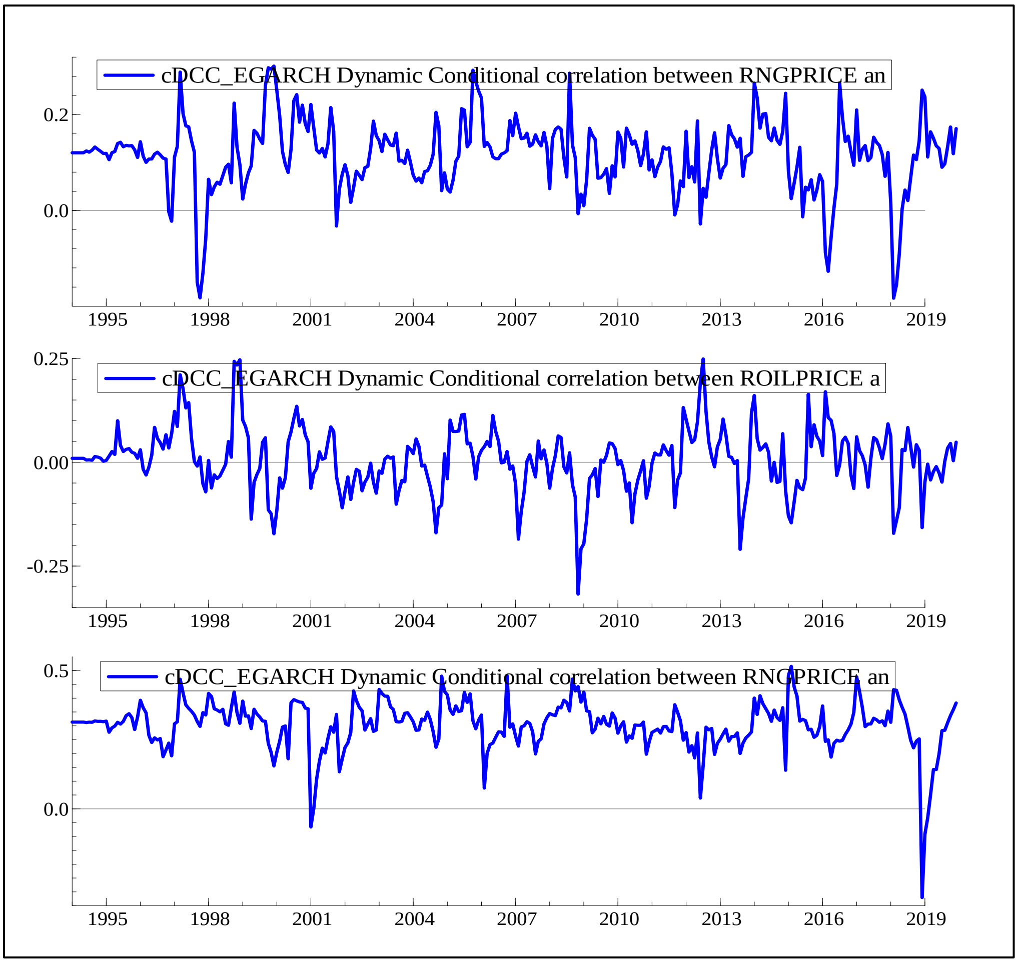
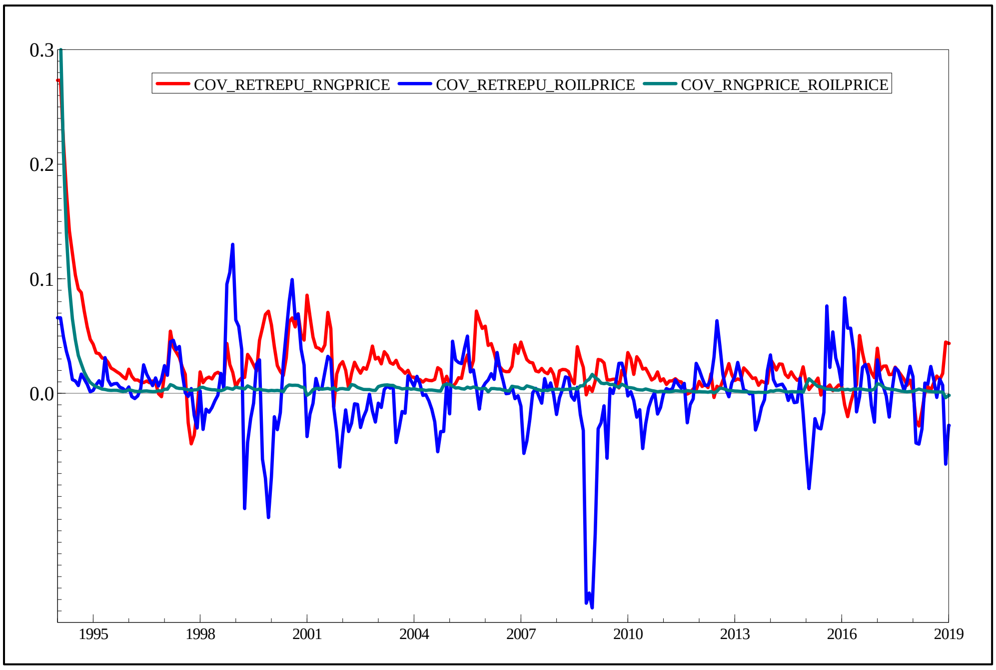


Figure 2: cDCC-EGARCH Dynamic Conditional correlations between REPU uncertainty and energy prices**.**



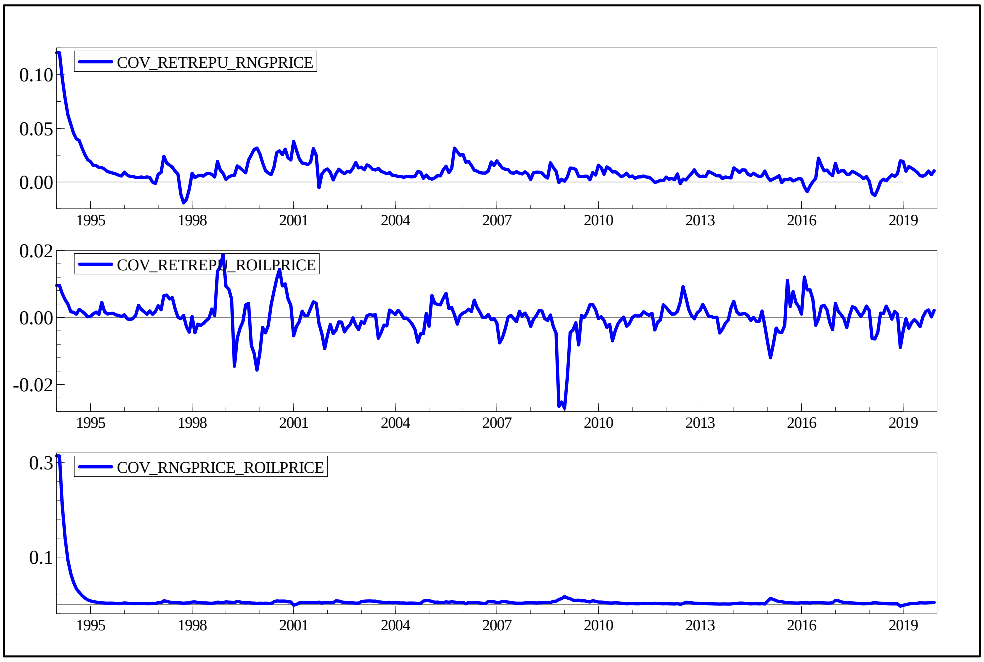


Figure 3: conditional covariance of Russian economic policy uncertainty and energy prices**.**

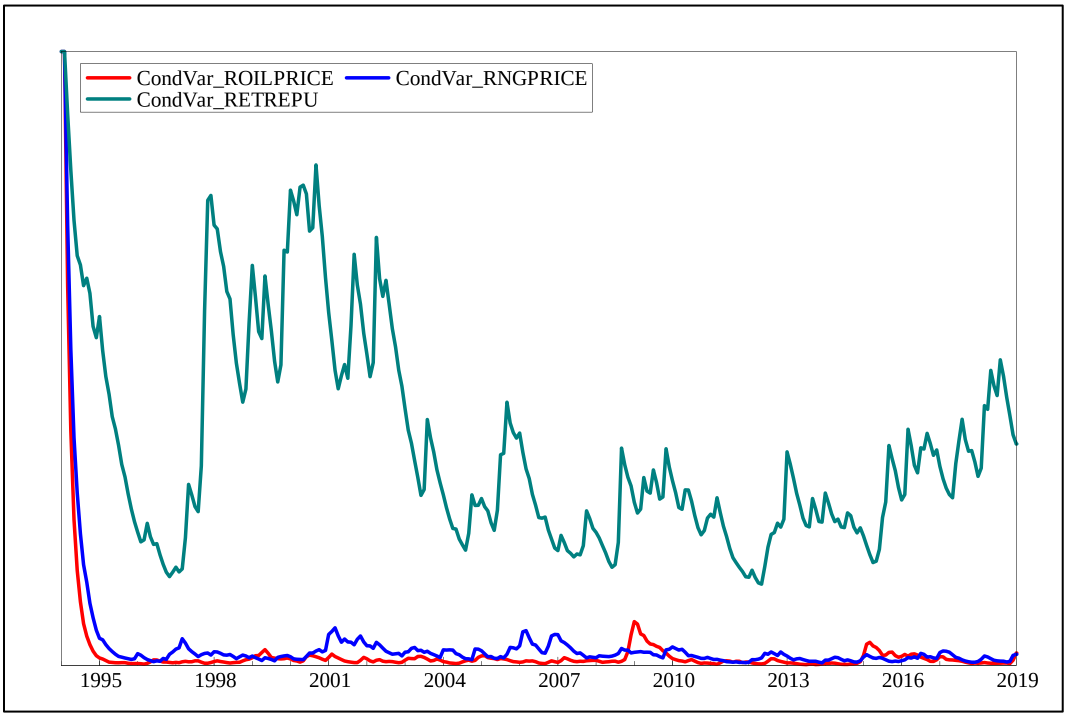


Figure 4: conditional volatilities of EPU and energy prices

Figure 3 displays the covariance between the oil price, natural gas price, and EPU. The graph shows the time-varying nature of the conditional covariance with the covariance between gas price and EPU. The covariance between oil price and EPU notably plummeted in 2008, an indication of the effect of the global financial crisis. The graph also illustrates that covariance between oil prices and gas prices are smooth throughout the period. This demonstrates the close connection between energy prices. Besides, the covariance between gas price and economic policy uncertainty is the highest, depicting the substantial effect of natural gas on the Russian economic policy decisions. Similarly, figure 4 illustrates the conditional volatilities of the three variables. The graphical display portrays the dynamic nature of the conditional volatilities of all the variables. It shows that the conditional volatility of the Russian economic policy volatility is the highest followed by the natural gas price returns over the period. Therefore, the conditional correlations, volatilities, and covariance are dynamic and depict interconnectedness of the Russian economic policy uncertainty and energy prices.

2.5 Conclusion

This chapter examined the interconnections between Russian EPU and energy prices using DCC-MGARCH models. Natural gas and crude oil are important to Russian economy. However, it is important to understand the dynamic relationship between energy prices and economic policy uncertainty in the country. Thus, we evaluated the interdependence of Russian EPU and energy price for the period 1994-2019. The energy prices and the economic policy uncertainty are volatile. Thus, we employ the volatility models. The preliminary results indicate the mean-reverting volatility of all three variables. However, when there is a shock, for instance, on the natural gas supply in Russia, the effect on the price lasts longer than the effect of a similar shock on crude oil supply. This current chapter further reveals interconnections between Russia EPU and energy prices. There is no neutrality among the variables. However, the conditional correlation among EPU and natural gas prices is greater than that of EPU and crude oil prices. Albeit, Russia is an important actor in energy markets, the co-movement of EPU is more with natural gas prices compare to that of crude oil prices.

This demonstrates how importance is natural gas to Russian economy. Russia is the 2rd biggest producer and top exporter of natural gas in the world. Hence, is reasonable for EPU to correlate more with natural gas prices that crude oil prices.

It is important to add that the correlation between EPU and both natural gas price and crude oil price follows the same pattern.

Both decline approximately at the same time and equivalently increase together. Also, the outcome of the chapter indicate that the some international events like the global recession, the Russian recession, the 9/11 and the ongoing way between Russia and Ukraine affect the interaction among REPU and gas prices.

Chapter 3

THE IMPACT OF UNITED STATES EPU ON FINANCIAL STABILITY IN BRICS ECONOMIES

3.1 Introduction

The financial sector is an integral part of an economic system; the sector plays a significant role in the management and utilization of the flow of funds and resources in an economic system. A stable financial system is essential for the efficient allocating of funds and enhancement of productivity, which results in stable and steady economic growth (Levine, 1997; Rajan & Zingales, 2003). A good financial system improves business activities and gives people easy access to financial services. Furthermore, a stable financial system increases economic activity and provides low-interest loans to investors, which leads to an increase in productivity and trade (Morris, 2010). According to (Mishkin, 1999) a sound financial system eases the process of transferring funds from savers to investors, which leads to a further increase in investment activities and efficient allocation of scarce resources.

There is no consensus in the literature on the definition of financial stability. For example, (Mishkin, 1999)defines financial stability as a situation where shocks do not interfere with the flow of information in a financial system, therefore the system works efficiently by distributing the available funds to productive investors. According to (Schinasi, 2004)financial stability is the ability to promote and improve a financial system, reduction of risk, and resistance to economic and financial shocks. (Allen & Wood, 2006) defined financial stability as a steady and stable increase in household income, which leads to an increase in household expenditure. They further consider the stable financial system as a system that can resist internal and external, expected and unexpected shocks that can destabilize the system. Financial stability is effective and efficient functioning of the financial market, financial institutions, financial intermediaries, and other elements of the financial system (Čihák, 2007). Financial stability is characterized by resilience to financial imbalances in a financial system which is resulted from the system or unexpected external circumstances (Phan et al., 2021). Financial stability is the ability of a financial system to perform its functions effectively by providing funds for investment, allocation of savings, management of risk, and resilience to shock (Buch & Weigert, 2021). According to the (World Bank, 2019), financial stability is the absence of events that destabilize the financial system. Financial stability is also considered as the position in which a financial system can resist shocks and instability in the elements of the financial structure, namely financial organizations, financial infrastructure, and financial markets (European Central Bank, 2020). Combining all the above definitions we conclude that financial stability is the situation where a financial structure is functioning efficiently and effectively by resisting all internal and external shocks that can disrupt the system.

EPU has a large and extensive impact on the economy at both micro and macro levels. EPU has a great influence on household consumption decisions, producer's investment decisions, unemployment, and overall economic growth (Bloom, 2009). Before the 2008 global financial crisis, the economic policy uncertainty index formulated by (Baker et al., 2016) was relatively constant, the index experience a significant increase as a result of the financial crisis. Following the global financial crisis, the world has encountered sequences of policy-related instabilities. These instabilities comprise events like the trade war between US and China and the European debt dilemma. Moreover, events like the 2016 United States presidential election and the Brexit choice by the United Kingdom described how the rise in economic policy uncertainty can produce imbalances in different financial markets. The global economic deterioration has significantly increased EPU in many nations (Balcilar et al., 2020)

According to (Mishkin, 1999), theoretically; an increase in uncertainty destabilizes information flow, hence, making the attribute of the borrowers vague. Amid the uncertainty period, lenders encounter difficulties in differentiating between favorable and harmful credit risks. Therefore, the lenders are averse to giving loans, resulting in to decrease in investment, and therefore, a decline in economic activities. (Minsky, 1970), further reveals that financial stability decreases following a lengthy economic improvement. Hence, an unexpected shock can cause a significant change in the financial structure. Moreover, (Minsky, 1970) described 2 unanticipated events can lessen the financial structure, human error and a shortage of funds stream because of decrease in income. The two conditions are highly possible during the period of uncertainty. Therefore, uncertainty is an important factor in financial stability.

BRICS is a bloc of developing countries namely, Brazil, Russia, India, China, and South Africa. BRICS countries have great influence in their various regions because of the significant role they play in terms of production and supply of both intermediaries and final goods and services, the countries are expected to dominate the global supply of final goods and services and raw materials in 2050. BRICS countries account for about 23% of the global GDP ($18.6 trillion) in 2014, the group also accounts for 41% of the global population; all the member countries except South Africa were among the top ten countries with high GDP (Reuters, 2021). The BRICS group's average GDP is higher than the global GDP between the periods of 1990 to 2010 based on the Gross Domestic Product (World bank Development Indicators, 2016). Speedy economic growth requires a stable financial system and reliable political and economic policies, after the global financial crisis the world has experienced several episodes of financial instability and fluctuations in economic and political policies. According to (Lieber, 2014) BRICS countries' economies grow faster than other developing countries. Therefore, developing and developed countries consider the BRICS countries as role models in terms of both economic and financial development.

According to (Li et al., 2020) the United States EPU plays a significant role in the portfolio market in China and India, the study further, revealed that an increase in US EPU decreases portfolio investments in India and China. Conversely, it is recorded that the US EPU positively influences the stock market in the BRICS economy (Kumar et al., 2020). According to (Dakhlaoui & Aloui, 2016), there is a negative relationship between US EPU and the BRICS stock market. A similar study (Sum, 2013) discovered a negative relationship between US economic policy uncertainty and the BRICS stock market. Therefore, US economic policy uncertainty is transmitted to the BRICS economy via portfolio investments. In light of these, the current chapter is aimed at investigating the impact of EPU on the financial stability in the BRICS.

Many studies have examined the relationship between EPU and other variables that are closely related to financial stability. According to our investigations only (Phan et al., 2021) specifically, investigate the association between financial stability and EPU for a For a group of 23 economies from 1996 to 2016 . This chapter differs from (Phan et al., 2021) by focusing on BRICS economies, which are considered as the five most popular emerging economies globally. The BRICS club's aggregate population is a 2.23 billion people, which is above 40% of the global population; the population of BRICS economies from 2000 to 2020 is represented in figure 5. The aggregate gross domestic product of the block is above $23.5 trillion, which is marginally higher than the GDP of the US (O'Neill, 2021), the gross domestic product of BRICS economies over the period of 2000 to 2020 is represent in figure 6. Moreover, the combined exports of goods and services for BRICS countries are $3494.46, which is about 20% of the global export of goods and services. The combined import of goods and services for the BRICS economies is $2920.79, which is about 16% of the total global import of goods and services (World Trade Statistical Review, 2021), the import and export are represented in figure 7 and 8 respectively. BRICS countries are different in terms of characteristics, they have different goals, values, and resources, the only common character they have is the BRICS membership. China is a communist country ruled by a single political party; Russia is a federal semi-presidential republic, while India and Brazil are democratic. Russia and China are permanent members of the United Nations Security Council; South Africa, Brazil, and India are not. All the countries have different financial system structures, equality, income, health, and education. We also use the US EPU index not the country-specific EPU index and the period of the study is from 2003 to 2020. Therefore, this chapter contributes to the literature by investigating the effect of the US EPU index on BRICS economies' financial stability. The rest of the chapter is structured as follows, the literature review is presented in section two, section three entails the data and .methodology and description of data, the explanations of the outcomes in section four, conclusions and policy implications are presented in the last section.

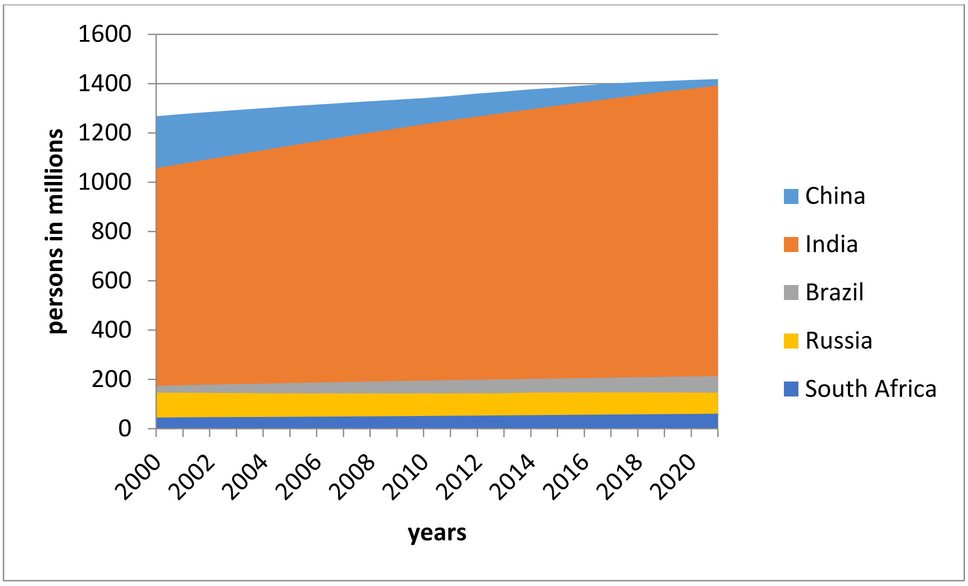


Figure 5: Aggregate Population of BRICS nations for the period of 2000-2020 (in million persons)

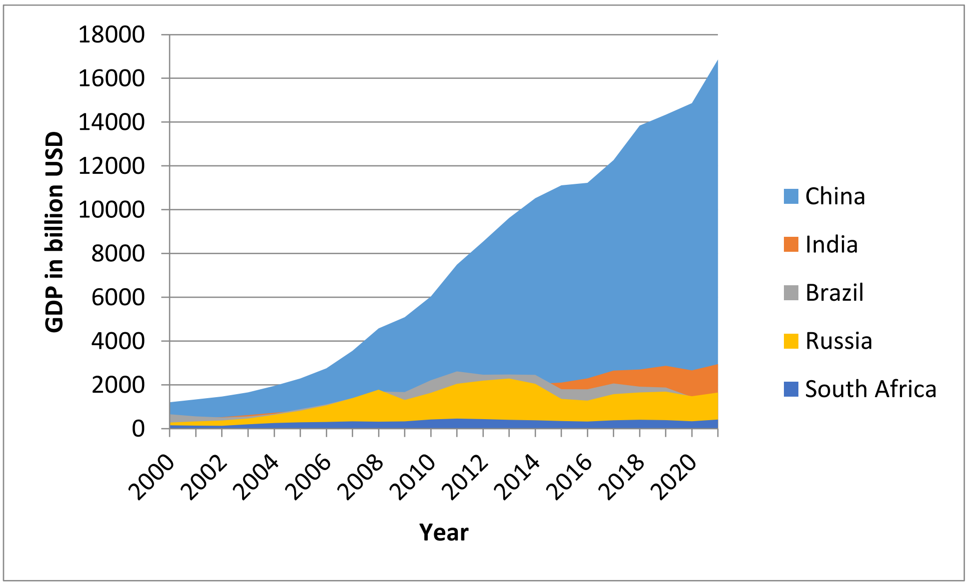


Figure 6: GDP of BRICS nations for the period of 2000-2020 (in billion USD)

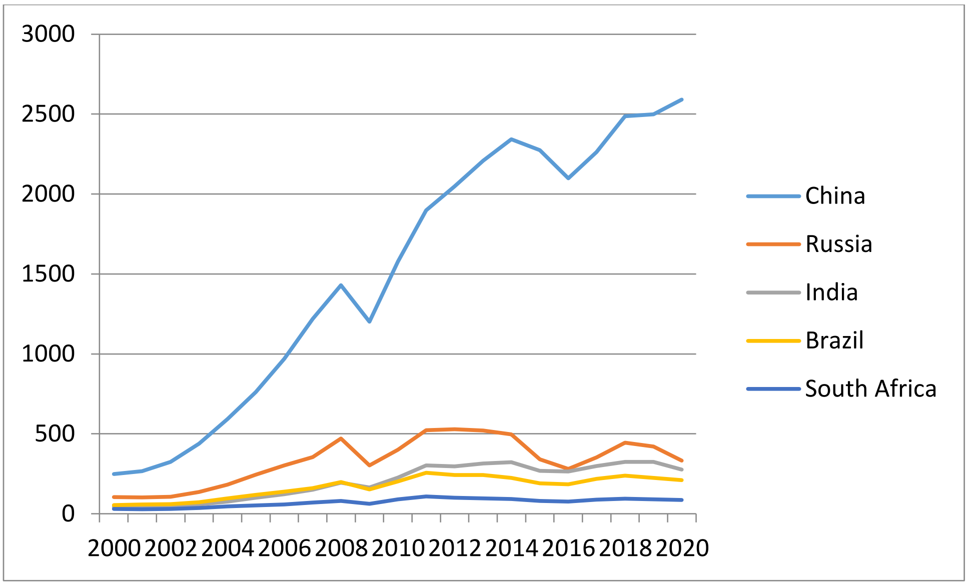


Figure 7: Import of goods and services into BRICS nations for the period of 2000-2020 (in billion USD)

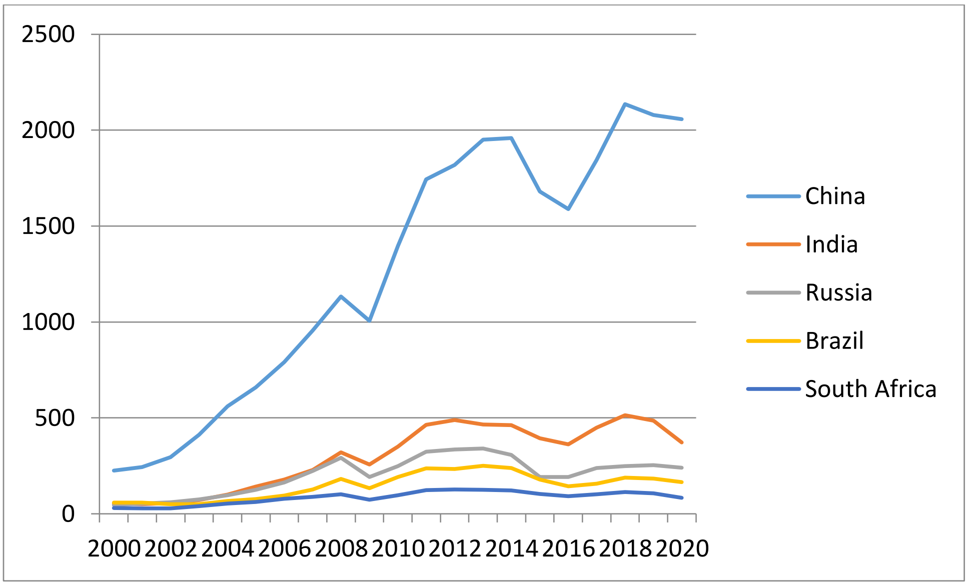


Figure 8: Export by BRICS nations (in billion USD)

3.2 Literature Review

Many studies have examined the relationship between financial stability and GDP. Some of these studies include; (Manu et al., 2011), studied the association among GDP and financial stability for African nations, by employing DFEM, the study recorded a positive relationship between financial stability and economic growth.

The study of (Creel et al., 2015) investigated the links between financial stability and GDP in European Union, from 1998 to 2011, according to findings of the study, financial instability harms economic growth. Another research investigate the link among bank competition, financial stability and GDP for a group of 32 European economies from 2001 to 2017, .the empirical outcomes reveal that low competition among banks has a positive effect on both financial stability and economic growth (Ijaz et al., 2020).

The study of (Younsi & Nafla, 2019) investigate the association between financial stability, monetary policy, and GDP for a panel of selected developing and developed countries for the period of 1993-2015. The main findings of the study show that an increase in financial stability improves economic growth. The empirical work of (Sotiropoulou et al., 2019) examines the relationship between financial development, financial stability, and GDP for a panel of 28 European countries for the period of 2004-2014. The findings of the study signified a negative relationship between financial instability and economic growth. The study of (Alsamara et al., 2019) analyze the relationship between financial stability and economic growth of Qatar for the period of 1980-2013 by applying VECM with structural break technique. The empirical findings record a positive relationship between financial stability and economic growth. The empirical research of (Tosunoglu, 2018) study the relationship between financial stability and economic growth in Turkey for the period of 2002-2017, according to the findings of the study, a stable financial system enhances economic growth. The study of (Ahulu et al., 2021) investigated the relationship between financial stability and economic growth for Sub-Saharan Africa throughout 2010 to 2019. The result shows that a 71.8% variation of a country's GDP is accounted for by financial stability.

We also review some studies that examined the relationship between EPU and GDP The study of (Istiak & Serletis, 2018) examined the interconnections between GDP and EPU of G7 countries for the period of 1985-2015, the findings of the study revealed a negative relationship between EPU and real output. The research work of (Bhagat et al., 2016) discovered a negative and significant relationship between EPU and GDP and investment in India. A similar study of (Sahinoz & Erdogan Cosar, 2018) reports a links among EPU, consumption, economic activities and investment in Turkey. In another study, (Chen et al., 2019) document a negative relationship between global economic policy uncertainty and Chinese industrial economic growth; the study further documents a positive relationship between global oil prices and Chinese industrial economic growth. According to (Adedoyin & Zakari, 2020) an increase in economic policy uncertainty results in an unhealthy economy in the United Kingdom from 1985 through 2017. The study of (Erer & Erer, 2020) investigated the impact of United States economic policy uncertainty on the economic growth of a panel of developing countries, the findings of the study suggest a negative relationship between EPU and GDP.

Tuning towards the researches that investigates the interconnection among EPU and other finance-related variables; the empirical study of (Balcilar et al., 2020) investigate the relationship between insurance and economic policy uncertainty for a panel of 15 countries using annual data between 1998 and 2016, the study discovered a positive relationship between economic policy uncertainty and insurance premium both in the short-run and long run. The study of (Demir et al.,

2018) examines the predictive impact of economic policy uncertainty on bitcoin return, the findings reveal that economic policy uncertainty has predictive power on bitcoin returns, the findings further discovered an increase in economic policy uncertainty reduces bitcoin return, the study also documents that economic policy uncertainty has a hedging potential contrast to the uncertainty. The research of (Caglayan & Xu, 2019) analyzed the effect of economic policy uncertainty on credit and stability of financial institutions in a panel of 18 countries, the findings of the study revealed that an increase in EPU is associated with a decrease in available credits and distract the stability of the financial institutions. According to (Danisman et al., 2021) EPU decreases bank credit in a panel of 19 countries.

The work of (L. Liu & Zhang, 2015) recorded a positive and significant corrections between stock market fluctuations and EPU. The study (Ko & Lee, 2015)discovered a negative and statistically significant relationship between EPU and stocks. EPU negatively affects stock market synchronicity in China (Chen et al., 2019). In a similar study, a negative relationship is discovered between EPU and stock price (Ko & Lee, 2015). High EPU significantly decreases stocks returns for the period of 1990-2014 in the US (Arouri et al., 2016). (Ashraf & Shen, 2019) discovered a positive interconnection between EPU and the interest rate on Banks loan. According to (Karadima & Louri, 2021) economic policy uncertainty has a positive influence on non-performing loans in four major countries in the Eurozone namely, Germany, France, Spain, and Italy. The empirical work of (Phan et al., 2021), examine the interconnection between EPU and financial stability for a group of 23 economies for the period of 1996-2016. The outcomes of the research revealed the existence of a negative and statistically significant relationship between EPU and financial stability.

3.3 Data, Model, and Methodology

3.3.1 Data

To investigate the impact of economic policy uncertainty on financial stability, the current chapter employed annual time series data from 2003 to 2020 for BRICS economies. The variables uses in this chapter are as follows, financial stability is proxy by z-score. The banks z-score has been universally used as a measure for bank insolvency risk in both practical and academic studies. Therefore, bank insolvency is generally considered as a situation where the return on asset plus equity to asset ratio is less than or equal to zero. According to (Lepetit & Strobel, 2015), if the return on asset is a random variable with limited average (µROA) and variance (σ2 ROA), the one-tailed Markov's inequality provides an upper limit of the possibility of insolvency as a nonlinear function of Z-score which is computed as the ratio of total banks' return on asset plus equity to asset ratio divided by the standard deviation of return on asset.

$$\text{Z-score} = \frac{ROA + {}^{Equty}/_{Asset}}{\sigma ROA} > 0 \quad (7)$$

Where ROA stands for return on asset and σROA stands for the standard deviation of return on asset.

Hence, $P(ROA \leq -Equit/Asset) \leq (1 + z^2) < 1$ (8)

In this regard, a high Z-score indicates a low possibility of insolvency. Hence, a high Z-score implies financial stability, and a low Z-score means financial instability. Z-score is widely used as the proxy of financial stability in the literature, some of the studies that used Z-score as a proxy for financial stability include, (Chiaramonte et al., 2016; Dahir et al., 2018; Ijaz et al., 2020; Lepetit & Strobel, 2015; X. Li et al., 2017; Phan et al., 2021; Urolagin et al., 2021).

We further use the United States EPU index formulated by (Baker et al., 2016); The US EPU index is available at EPU website (http://www.policyuncertainty.com/). The control variables used in this chapter include the gross domestic product (GDP) per capita, trade openness, exchange rate, Inflation rate, domestic credit to private sector and gross capital formation, all the data are sourced from the World Bank development indicators (WDI, 2016).

3.3.2 Model Specification

The model specification is as flows:

$$Z - Score\ (EPUit, GDPPCit, TOit, EXCit, INFit, DCit, CFit) \qquad (9)$$

$$lnZ - Scoreit = \beta 0 + \beta 1lnEPUit + \beta 2lnGDPPCit + \beta 3lnTOit + \beta 4lnEXCit + \beta 5lnINFit + \beta 6lnDCit + \beta 7lnCFit + \varepsilon \qquad (10)$$

Where Z-Score refers to financial stability, EPU refers to US EPU, GDPPC represents gross domestic product per capita, TO stands for trade openness, EXC exchange rate, INF is the inflation rate, DC stands for domestic credit to private sector and CF is gross capital formation. β_0 is the intercept coefficient, β_1, β_2 β_3, β_4, β_5, β_6 and β_7 are slope coefficients and ε refers to the error term. The subscript i represents the countries and t refers to the years.

According to the theory (Minsky, 1970) and (Mishkin, 1999), the expected sign of economic policy uncertainty is negative. We expect an increase in EPU to induce an increase in financial insatiability. According to the financial instability, the proposition asserts that economic growth enhances financial stability (Mishkin, 1999). Hence, GDPPC is expected to have a positive sign. A high level of trade openness improves financial stability (Albulescu, 2009; Kono & Schuknecht, 1999; Rahman et al., 2020). Thus, we expected trade openness to have a positive sign. The exchange rate is expected to have a negative sign (Eichengreen, 1998; Fornaro, 2015). A rise in inflation is associated with a high financial instability (Bordo et al., 2003; Huybens & Smith, 1999; Issing, 2003). Therefore, the inflation rate is expected to have a negative sign.

3.3.3 Methodology

3.3.3.1 Cross-sectional Dependency Test (CD)

A high rate of interconnectedness and interdependence between countries across the world have developed in broadening interrelationship between nations, hence, nations included in the panel can be cross-sectional dependent. Therefore, it is essential to carry out the cross-sectional dependency test for the countries included in this study. So, it is logical to expect the existence of cross-sectional dependency in the panel. Hence, we conducted the (Pesaran, 2004a) and the (Breusch & Pagan, 1980) Lagrange multiplier (LM) cross-sectional dependency (CD) test. Below is the equation for (Pesaran, 2004a) CD test:

$$CD = \sqrt{\frac{2W}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} (W-K) \frac{\hat{\rho}_{ij}^2 - E(W-K)\hat{\rho}_{ij}^2}{\sigma^2 \, (W-K)\hat{\rho}_{ij}^2} \quad (11)$$

Where $\hat{\rho}_{ij}^2$ is the expected correlation coefficient extracted from the residuals of the ordinary least square model. Below is the specification of the (Breusch & Pagan, 1980) LM test:

$$LM = T_{ij} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij}^2 \rightarrow x^2 \, \frac{N(N-1)}{2} \quad (12)$$

Where N and T are the numbers of countries and years respectively.

3.3.3.2 Panel Unit Root Test

The conventional first-generation panel unit root tests only deal with cross-sectional independence; it does not capture the cross-sectional dependency (CD) problem. The second generation panel unit root test deals with the CD problem. Hence, upon realization of the cross-sectional dependency problem, we applied the second-generation panel unit root tests. We employed the cross-sectional augmented Dickey-Fuller (CADF) and the cross-sectional Im, Pesaran, and Shin (CIPS) panel unit root analysis methods recommended by (Pesaran, 2007) Below is the generalized regression that the CADF test statistic can be generated from:

$$\Delta x_{it} = \partial_{1i} + \partial_2 x_{i,t-1} + \partial_3 \bar{x}_{t-1} + \sum_{j=0}^{s} \partial_{4ij} \Delta \bar{x}_{t-j} + \sum_{j=1}^{s} \partial_{5ij} \Delta \bar{x}_{i,t-1} + \epsilon_{it} \quad (13)$$

Where $\bar{x}$ and $\Delta\bar{x}$ are the means of the cross-sectional lag at the level and the first difference, accordingly, for all cross-sections at time T. The CIPS statistic is computed from the t-statistic calculated from equation (5), the CIPS statistic is presented in the equation below;

$$cips = M^{-1} \sum_{i=1}^{M} cadf_i \quad (14)$$

Where $cadf_i$ stands for the t-statistic computed from the equation (5). The null hypotheses for both CIPS and CADF are, the series are non-stationary and the alternative hypotheses are the series stationary.

3.3.3.3 Panel Cointegration Test

The conventional (Pedroni, 2004) residual-based panel cointegration technique does not address the issue of cross-sectional dependency between the panels. Therefore, we employed the (Westerlund & Edgerton, 2007) panel cointegration method, which deals with the problem of cross-sectional dependency to examine the long-run relationship among our variables of interest. Bootstrapping technique is the approach used in calculating the probability values of the test statistic for the (Westerlund & Edgerton, 2007) panel cointegration method. An aggregate of two group-average analysis and panel analysis is carried out under the H0≠ cointegration and H1= cointegration between one or all the cross-sectional groups. Below is the error correction model structure that is applied to test the four tests under the (Westerlund & Edgerton, 2007) panel cointegration method:

$$\Delta x_{it} = \theta_i' d_t + \varphi_i\left(x_{i,t-1} - \emptyset_i' z_{i,t-1}\right) + \sum_{j=1}^{p_i} \varphi_{ij}\, \Delta x_{i,t-1} + \sum_{-qi}^{p_i} \vartheta_{ij}\, \Delta z_{i,t-j} + \epsilon_{it} \quad (15)$$

Where d_t represents the deterministic elements, p_ii stands for lag length and qi stands for leads orders, p_ii and qi are permitted to change among individual cross-sections. Below is the specification of the two group-average analysis statistics and two-panel analysis statistics under the Westerlund:

$$G_\tau = \frac{1}{N} \sum_{i=1}^{N} \frac{\emptyset_i}{SE(\emptyset_i)} \quad (16)$$

$$G_\alpha = \frac{1}{N} \sum_{i=1}^{N} \frac{T\emptyset_i}{\emptyset_i(1)} \quad (17)$$

$$P_\tau = \frac{\emptyset_i}{SE(\emptyset_i)} \quad (18)$$

$$P_\alpha = T\emptyset_. \quad (19)$$

The null hypothesis is no cointegration among the variables against the alternative hypothesis of cointegration among the variables. The exitance of cointegration among the variable is a pre-condition to estimating the long-run relations applying the suitable regression techniques.

3.3.3.4 Estimations

The conventional fully modified ordinary least square (FMOLS) and dynamic ordinary least square (DOLS) panel data analysis accounts for cross-sectional dependency among the panel but does not account for slope heterogeneity problem, FMOLS and DOLS consider the presence of homogenous slope coefficients among the entire cross-section. The consequences of the slope heterogeneity problem are similar to that of CD problem; they all result in the problem of misspecification. To correct for the problems mentioned above, we employ the Mean Group (MG) estimator formulated by (Pesaran & Smith, 1995a) and the Common Correlated Effects Mean Group (CCFMG) estimator formulated by (Pesaran, 2006) we further employ the Augmented Mean Group (AMG) estimators formulated by (Bond & Eberhardt, 2013) for robustness check. Below is the MG model specification:

$$\hat{\alpha}_{MG} = N^{-1} \sum_{i=1}^{N} \hat{\alpha}_i \tag{20}$$

Where $\hat{\alpha}_{MG}$ stands for the individual means of the coefficient of the variable of each member of the cross-section. Below is the equation for CCFMG model:

$$\text{CCFMG} = \frac{1}{N} \sum_{i=i}^{N} \hat{\beta}_i \tag{21}$$

Where $\hat{\beta}_i$ denotes the individual or cross-section coefficient extracted from ordinary least square regression.

3.3.3.5 Dumitrescu-Hurlin Panel Non-causality Tests.

The conventional Pairwise Granger causality test approach proposed by (Granger, 1969) doesn't capture the issue of CD, Hence, dependency and heterogeneity. Therefore, we utilize the (Dumitrescu & Hurlin, 2012) non-causality technique to examine the interconnection between the variables of interest. Furthermore, the Dumitrescu-Hurlin non-causality technique produces prosperous estimates for a panel series with few countries like the current study (Dumitrescu & Hurlin, 2012). Below is the specification of the Dumitrescu-Hurlin non-causality test:

$$x_{it} = \alpha_i + \sum_{i=1}^{\rho} \beta_i^{\rho} x_{i,1-\rho} + \sum_{i-1}^{\rho} \theta_i^{\rho} z_{i,1-\rho}^{\rho} + \varepsilon_{i,t} \tag{22}$$

Where ρ is a constant, α_i, β_i^{ρ} and θ_i^{ρ} are slope coefficients and lag parameters. The null hypothesis of Dumitrescu-Hurlin is, there is no causality among the cross-section and the alternative hypothesis is there is causality between the cross-sectional. Below is the definition of the null and alternative hypothesis of the Dumitrescu-Hurlin non-causality test:

H_0: $\theta_i = 0$ (z_{it} does not granger cause x_{it})

H_{A1}: $\theta_i = 0$ $\forall_i = 1, 2 \ldots. N$ (z_{it} does not granger cause x_{it})

H_{A2}: $\theta_i \neq 0$ $\forall_i = N_1+1, N_1+2 \ldots. N$ (z_{it} granger cause x_{it})

Where $0 \leq N_1 N^{-1} \leq 1$

$$\overline{S} \leq N^{-1} \sum_{i=1}^{N} S_i \quad (23)$$

Where $\overline{S}$ is the mean of S_i and S_i in the cross-section Wald statistic in time.

If S_i is mutually independent and have the same probability distribution in all cross-sections, the equation for $\bar{Z}$ (linear combination of $\overline{S}$ and R) is as follows:

$$\bar{Z} = \sqrt{(N)2R^{-1}(\overline{S} - R) \rightarrow N(0,1)} \quad (24)$$

The equation below defines the standardized statistic ($\breve{Z}$), which is normally distributed and also corrected for a fixed time magnitude.

$$\breve{Z} = \sqrt{(N)2R^{-1} * \frac{(T-2R-5)}{(T-R-3)} * \left[\frac{(T-2R-3)}{(T-2R-1)} \overline{S} - R\right] \rightarrow N(0,1)} \quad (25)$$

3.4. Results and Discussions

Table 5 entails the descriptive statistical information about all the variables of interest. The average annual financial stability (Z-SCORE) is about 14.41712 while the average US economic policy uncertainty index (EPU) is about 1507.303, which is below the normalized value (100) of the index ascribed to 1997 considered as a relatively low uncertainty period (Davis, 2016). The average gross domestic product per capita (GDPPC) is 11832.26, the average trade openness is 3.84000, the averages of the exchange rate (EXC) and that of inflation rate (INF) are

0.146511and 5.858227 respectively. The mean of domestic credit to private sector (DC) is 80.28632 and the mean of gross capital formation (CF) is 9.5400. The maximum values of the Z-score, EPU, GDPPC TO, EXC, INF, DC and CF are 3.135294, 8.332761, 10.20903, 26.24589, 1.366984, 2.759296, 182.8681 and 6.3700 while the minimum values are 1.731516, 6.558474, 6.303949, 3.095848, -4.688394, 0.120093, 21.24357 and 3.0800 respectively. Z-SCORE is skewed to the left (negative skewness), EPU and other variables are skewed to the right (positive skewness) while the kurtosis shows that Z-SCORE, GDPPC, INF and DC are lightly-tailed (kurtosis less than 3) while EPU, TO, EXC, INF and CF are heavily-tailed (kurtosis greater than 3). Thus, the skewness and kurtosis indicate that EPU, TO, EXC, INF and CF are not normally distributed and the remaining variables considered in this study are normally distributed. The Jarque-Bera test statistics, which are significant for EPU, TO, EXC, INF, DC and CF equally indicate the rejection of the normality of the distributions of the series.

Table 5: Descriptive statistics

	z_score	epu	gdppc	to	Exc	inf	dc	Cf
Mean	14.4171	1507.30	11832.6	3.840	0.14651	5.85827	80.286	9.540
Median	15.0848	1312.19	12424.8	47.918	0.07969	5.21181	59.629	3.670
Maximum	22.9954	4157.88	27147.33	2.500	3.92350	15.7887	182.86	6.370
Minimum	5.64921	705.194	546.727	22.106	-1.93870	-1.63450	21.244	3.080
Std. Dev.	4.37915	768.729	7234.617	7.950	0.73166	3.54294	42.421	1.550
Skewness	-0.42244	1.33519	0.169444	1.6765	1.49398	0.82994	0.5113	2.326
Kurtosis	2.45049	4.44820	2.476626	4.0102	12.4904	3.57633	1.8475	7.196
Jarque-Bera	3.80926	34.6058	1.457868	45.986	371.239	11.5776	8.9016	147.12
Probabilit	0.14888	0.0000	0.482423	0.0000	0.00000	0.00306	0.0117	0.000

y								
Sum	1297.54	135657	1064904.	3.460	13.1859	527.240	7225.8	8.590
Sum Sq.Dev.	1706.75	5259416	4.660	5.630	47.6459	1117.17	16016	2.120
Observations	90	90	90	90	90	90	90	90

Table 6 contains the correlation information of the variables; the correlation coefficients for all pairs of the variables are below 0.5 excluding GDPPC, indicating the absence of multicollinearity problem among our variables.

Table 6: Correlation metrix

correlation	z_score	epu	gdppc	to	exc	inf	dc	cf
z_score	1.0000							
epu	0.27695	1.0000						
gdppc	0.6682	0.4887	1.0000					
to	-0.0400	0.1388	0.0238	1.0000				
exc	-0.0095	0.0282	0.0533	0.2444	1.0000			
inf	-0.2255	0.3090	0.0529	-0.1143	0.0514	1.0000		
dc	0.39199	-0.1818	0.0479	0.5040	0.0975	-0.5581	1.0000	
cf	0.4916	-0.2419	0.0650	-0.2812	-0.0371	-0.3856	0.5887	1.0000

Before proceeding with the unit root test, we begin with the cross-sectional dependency (CSD) test among our panel. The results of the CSD test are presented in table 7. According to the table, we reject the null hypothesis at a 5% level of significance of no CSD among our variables. Hence, our result signifies the existence of CSD among the countries in our series. Therefore, we have to consider CSD across the countries in our successive empirical analysis.

Table 7: Cross-sectional dependence test results

Test	**Statistic**	**d.f.**	**Prob.**
Breusch-Pagan LM	41.06000***	10	0.0000
Pesaran scaled LM	6.945226***		0.0000
Pesaran CD	4.349280***		0.0000

*** denotes rejection at 5% significance level.

Time series are often non-stationary and have trend (Kwiatkowski et al., 1992) Therefore, the regression estimates of a non-stationary variable on another non-stationary variable(s) are spurious and leads to the wrong conclusion. Therefore, it is important to investigate the stationarity property of our series before moving to the next step in our empirical analysis. Moreover, the stationarity of the series is a prerequisite for the cointegration test. Therefore, we employ the second generation panel unit root test of CADF and CIPS. Table 8 consists of the outcomes of the unit root test. The outcomes of the two second generation unit root test reveal that; at a 5% level of significance, the level series of EPU, GDPPC domestic credit to private sector, gross capital formation and z-score are has unit root at the level. Hence, we take the first difference, the outcomes indicates that all our variables are stationary at first difference.

Table 8: Stationarity test

Variables	CIPS	CADF
	I(0)	I(0)
Z_SCORE	-1.15122	15.1376

EPU	-1.39719	15.8004
GDPPC	3.02388	1.76220
TO	0.06103	9.56844
EXC	0.49526	6.81110
INF	-1.30362	16.2230
DC	-0.04375	12.7887
CF	-0.32649	9.87447
	I(1)	I(1)
Z_SCORE	3.10665***	27.3389***
EPU	4.34632***	35.5605***
GDPPC	-2.47136***	22.3685***
TO	-3.36337***	28.5643***
EXC	-2.79478***	21.2947***
INF	-2.34514***	21.7984***
DC	-1.85787***	17.9712***
CF	-2.64819***	23.7854***

*** denotes rejection at 5% significance level, Schwarz Automatic lag selection criteria have been applied.

The result of the Westerlund cointegration test is presented in table 9, the outcome indicates the existence of long-run equilibrium relation among the variables of interest. Hence, we apply this formula; $\hat{\alpha} = P_{\alpha}/T$ (-2.894/17 = -0.17) to get the speed at which the variables are moving from short-run disequilibrium to long-run path. Therefore, our variables are moving towards their long-run equilibrium at a speed of 17% annually.

Table 9: Westerlund cointegration test results

Statistic	**Value**	**P-value**
$\boldsymbol{G_{\tau}}$	-3.006	0.012***
$\boldsymbol{G_{\alpha}}$	-2.783	0.009***
$\boldsymbol{P_{\tau}}$	-4.536	0.005***
$\boldsymbol{P_{\alpha}}$	-2.894	0.009***

Table 10: MG, AMG and CCFMG estimation results

Variables (dependent	MG	AMG	CCFMG

variable: lnZ_Score)			
lnEPU	-0. 08560	-0.02034	-0. 56240
	(0.6060)	(0.8100)	(0. 5960)
lnGDPPC	0.03460***	0. 22350***	0. 53480 ***
	(0.0000)	(0.0000)	(0.0099)
lnTO	7.53001	0. 08145 ***	0.02947 ***
	(0.3323)	(0.0050)	(0.0013)
lnEXC	- 0.144055	-18.71883 ***	- 57.4587
	(0.7127)	(0.0800)	(0. 1470)
lnINF	-0.076867***	-0 .0734228***	-0.05846***
	(0.0027)	(0.4170)	(0. 0519)
lnDC	-0.71270***	-0.13064***	-0.13642***
	(0.0125)	(0.0000)	(0.0220)
lnCF	7.60021***	3.2901	7.91000***
	(0.0618)	(0.0301)***	(0.0000)
Constant	6.822071***	0.85208	10.11095
	(0.0000)	(0.0605)	(0.4620)

*** denotes rejection at 5% significance level, ** represents 1% significance level, * represents 10% significance level, and the numbers in () are the P-values.

The outcomes of MG, AMG, and CCFMG models are presented in table ten. The negative coefficient of US economic policy uncertainty signifies a negative relationship between US economic policy uncertainty and BRICS economies financial stability. US EPU is also statistically insignificant, meaning US EPU does not play a vital role in BRICS financial stability. A 1% increase in US EPU denotes 0. 08560%, 0.02034% and 0.56240% increase in BRICS financial instability in MG, AMG, and CCFMG models respectively. There is an economic interpretation of the above finding. An increase in US economic policy uncertainty leads to a decrease in

BRICS countries' Z-score; a low z-score indicates a high possibility of insolvency, high insolvency implies financial instability. Hence, it is reasonable to conclude that an increase in US economic policy uncertainty increases financial instability in BRICS economies. Furthermore, an increase in the US EPU results in to decrease in portfolio investment in BRICS, which leads to a decrease in banks equity and return on asset, which further decreases the Z-score or decrease in financial stability. Since US EPU is statistically insignificant, hence US EPU does not significantly influence the BRICS financial stability. The findings of this chapter are inconsistent with the theory, as the theory suggests that there is a high possibility of financial instability during the uncertainty period. The findings are also not similar to that of (Phan et al., 2021), which also records rise in EPU is associated with financial instability.

The second independent variable in this study is the gross domestic product per capita, the coefficient of GDPPC is positive, meaning GDPPC is positively associated with Z-SCORE in all our three models. Therefore, an increase in GDPPC denotes an increase in financial stability, GDPPC is also statistically significant. A 1% average increment in GDPPC results to 0.03460% increase in Z-SCORE in MG model, 0. 22350% increase in AGM model and 0. 53480% increase in CCFMG model. The economic explanation is as follows; an increase in gross domestic product per capita (income) increases consumption and investment (components of GDP) which increases the GDP. According to the financial stability proposition by (Mishkin, 1999), an increase in GDP (economic growth) enhances financial stability. This finding is similar to the findings of (Manu et al., 2011). The coefficients of trade openness have a positive sign as expected in all the three models, which signifies a positive relationship between TO and Z_SCORE.

Therefore, a 1% increase in TO results in a 7.53001% increase in Z-SCROE in the MG model, a 1% increase in TO denote a 0.10400% increase in Z-SCORE and a 1% increase in TO increase Z-SCORE by 0.46300% in AMG model and CCFMG model respectively. Trade openness is statistically significant. Therefore, an increase in both export and import of goods and services between BRICS and other countries will enhance financial stability in BRICS. This is consistent with the findings of (Albulescu, 2009; Ashraf & Shen, 2019; Kono & Schuknecht, 1999; Rahman et al., 2020).

Conversely, the exchange rate is negatively related to financial stability and statistically significant. Hence EXC does not have much influence on Z-SCORE; a 1% increase in EXC denotes 0.050500% increase in Z-Score on the MG model, 0.046012% in the AMG model, and 0.049087% in CCFMG model respectively. Therefore, a high exchange rate decreases financial stability in BRICS, this finding is similar to that of (Eichengreen, 1998; Fornaro, 2015; Stoica & Ihnatov, 2016) Similarly, the coefficients of inflation rate also indicate a negative relationship between financial stability and inflation rate, meaning an increase in inflation rate results to a decrease in financial stability in BRICS; furthermore, INF is statistically significant in all our three models. A 1% increase in INF denotes a 0.106260% decrease in FD in MG model, 0.108269% in AMG model and 0.314951% in CCFMG model respectively. The findings are consistent with the findings of (Bordo et al., 2003; Huybens & Smith, 1999; Issing, 2003).

Domestic credit to private sector is negatively related to financial stability. Hence, an increase in domestic credit to private sector in BRICS economies decreases the financial stability of the countries. Our findings further discovered that domestic credit to private sector is statistically significant. According to MG model, a 1% increases in domestic credit to private sector results to 0.71270% decrease in financial stability, furthermore a 1% increase in domestic credit to private sector decreases financial stability 0.13064% and 0.13642 AMG and CCFMG models respectively. Moreover, our findings revealed that an increase in gross capital formation enhances financial stability in BRICS countries; gross capital formation is also statistically significant. 1% improves in gross capital formation leads to 7.60021%, 3.2901% and 7.91000% increase in financial stability in MG, AMG and CCFMG models respectively.

Table 11: Dumitrescu-Hurlin panel non-causality tests

Financial Stability	→	Gross Domestic Product Per Capita
Financial Stability	→	Exchange Rate
Financial Stability	→	Gross Capital Formation
Economic Policy Uncertainty	→	Gross Domestic Product Per Capita
Economic Policy Uncertainty	→	Trade Openness
Exchange Rate	→	Trade Openness
Inflation	→	Trade Openness
Gross Capital Formation	→	Trade Openness
Domestic Credit to Private Sector	→	Exchange Rate
Gross Capital Formation	→	Domestic Credit to Private Sector

↔ represent the bidirectional relationship, ← and → represent the Unidirectional relationship

Finally, the results of Dumitrescu-Hurlin panel non-causality tests are recorded in table 11; we discovered unidirectional causality from BRICS financial stability to gross domestic product per capita, exchange rate and gross capital formation. Hence, BRICS financial stability is an important predictor of gross domestic product per capita, exchange rate and gross capital formation. Moreover, we record unidirectional causality from GDPPC to exchange rate. Hence, gross domestic product is an important predictor of exchange rate. Finally, we record a unidirectional causality from gross capital formation to gross domestic product per capita and exchange rate. Therefore, gross capital formation is an important predictor of gross domestic product per capita and exchange rate.

3.5 Conclusion

This chapter examined the interconnections between BRICS economies' financial stability and US economic policy uncertainty using MG, AGM, and CCFMG models. Financial stability is important for BRICS economies. Thus, it is important to understand the relationship between financial stability and US EPU in the bloc. Therefore, this chapter evaluated the impact of US EPU on BRICS countries' financial stability over the period 2003-2020. According to the findings, financial stability, economic policy uncertainty, trade openness, exchange rate, inflation rate, domestic credit to private sector and gross capital formation are all integrated of order one, the chapter further discovered the existence of a long-run equilibrium relationship among our variables of interest. The variables are moving from the short-run disequilibrium to the long-run equilibrium at a speed of 17% annually. The main findings of this chapter show that an increase in US EPU increases BRICS economies' financial instability; moreover, US EPU does not influence BRICS financial stability. Conversely, an increase in BRICS gross domestic product per capita enhances financial stability in BRICS countries. The findings further reveal that increase in BRICS trade openness improves BRICS financial stability. While an increase in the exchange rate and inflation decreases financial stability. The findings further show that an increase in domestic credit to private sector decreases financial stability, while increase in gross capital formation increases financial stability. Moreover, we discovered that BRICS financial stability is an important predictor of gross domestic product per capita, exchange rate and gross capital formation. The main findings of the study confirmed the theory that holding other variables constant increase in uncertainty reduces financial stability; the findings are also similar to that of (Phan et al., 2021).

The findings of the current chapter are important for the following reasons. One, the study adds to the existing literature on the relationship between economic policy uncertainty and financial stability by investigating the impact of the US economic policy uncertainty index on BRICS economies' financial stability. Two, the chapter presents evidence that US EPU is not important to BRICS economies' financial stability. Finally, the chapter suggests that policymakers in BRICS countries should not pay much attention to US EPU in taking economic and political decisions. Future research can improve the literature by examining the relationship between EPU and other economic and financial variables, such as stability in the balance of payments.

Chapter 4

THE ROLE OF EPU AND FDI ON CONSUMPTION-BASE CARBON EMISSION IN G7 COUNTRIES

4.1 Introduction

The main aim of the Paris Climate agreement is to set global warning below 2 degrees Celsius; this target can be achieved by reducing the greenhouse gas emissions. It is a well-established fact that greenhouse gas emission contribute to global warming (Atasoy, 2017). Global warming is the major cause to climate change and environment degradation, which are the major issues faced by the modern world. The issue of environment quality has been attracting so much attention from researchers considering the vital role of environment quality to the life's of billions of people globally (Destek & Sarkodie, 2019). Carbon dioxide (CO2) accounts for 75% of the total greenhouse gas emission (IEA, 2019). The global temperature has increased by about 1.4^{0}C from 1980 to 2020 due to greenhouse emission (*NASA: Climate Change and Global Warming*, n.d.). The world has been experiencing series of environmental challenges due to climate change; events like heavy rainfall, droughts, heat waves and flood are among the challenges we are facing in our contemporary world. These challenges are seriously affecting ecosystems and the general well-being of humans (Diffenbaugh, 2020).

According to (Rothman, 1998), developed countries reduce carbon emission through international trade, but the concern here is that the emission is transferred to somewhere else, that is to the countries where the traded goods and services are produced or consumed. Therefore, trade play a significant role in both national and international carbon emissions, the volume of international trade has increased to about 62% from 2005 to 2015 (*World Trade* Statistical *Review 2021*, n.d.). International trade as percentage of gross domestic product has increased from 23% in 1960 to 58% in 2017 (*World* Trade *Statistical* Review *2021*, n.d.). The increase in the exchange of goods and services between countries is a significant factor that enhances carbon emissions (Hasanov et al., 2018).

Carbon emissions is generally measured in terms of production based, which is also referred to as territorial carbon emissions. The production base carbon emission accounting method is generally applied by countries to record their carbon emissions and set both their local and global targets. The studies of (Shahbaz et al., 2016; Yang et al., 2017) explored the impacts of production base carbon emission and scorned the consumption-base carbon emissions, which is aligned for international trade (import and export). Hence, statisticians differentiate the consumption-base carbon emission from the conventional territorial carbon emission in 1990; the carbon released from consumption of goods, services and other manufactured products is adjusted base on international trade. The method used to calculate the consumption-base emission is by adding import and subtracting export from the production base emission (Barrett et al., 2013). The studies (Z. Khan, Ali, Umar, et al., 2020a; Liddle, 2018a) are among the studies that investigates the effect of both production-base and consumption-base carbon emissions. The United States, Western Europe and many African countries are net-importers of CO2 emission, this means their consumption-base CO2 emission are higher than production-base CO2 emission, while China, some Asian countries and Eastern European Countries are net exporters of CO_2 emission (Peters et al., 2012).

Some major events of the past few years increase international economic and political uncertainty. The events started with the “Arab Spring” which causes a lot of unrest and changes of leadership styles in the Middle East and ended with the election of Joe Bidden as the president of the United State, which brings to an end of the regime of former president Donald Trump who was agitating for major reshaping in the global setting. There has been a great concern about the economic policies and the future of Europe, due to events like the decision of the United Kingdom’s exit from the European Union “Brexit”, other events includes the refuges crises and Russian invasion of Crimea. The ongoing global pandemic of COVID-19 has slow down the world economic activities due to high spread of the virus globally. Many enterprises have gone bankrupt because of the stay at home policies implemented by numerous countries, a large number of workforce has lost their means of livelihood (McKibbin & Fernando, 2020). Hence, Covid-19 pandemic have significantly increase political and economic uncertainty globally.

Global capital flows are the major characteristics of the current globalization in equity markets in both developed and emerging countries. These capital flows are done through Foreign Direct Investment (FDI) or Portfolio Investment (PI). Foreign Direct Investment is an investment by a foreigner in another country; FDI can be done through Greenfield investment or through accruing of an existing company. Hence, FDI involved the transfer of capital; knowledge, management, technology, good and service from one country to another (Voinea, 2013). Therefore, FDI grants the host country with an avenue to modern technologies and develop the knowledge of the local firms and further investment in research and development (R&D). FDI stream as a % of GDP is also use as the measure of the level of a country's connectivity to the world economy. FDI movements are calculated in USD as a percentage of gross domestic products. Moreover, FDI establishes steady and permanent connections between countries (OECD, 2021). FDI has been the major source of global capital movement over the past centuries. All G7 members are among the top 30 host countries of FDI inflows, the G7 members has experienced increase in FDI inflows from 1994 to 2019. In 2020, FDI inflows for G7 countries decreased by about 35% due to global Covid-19 pandemic (OECD, 2021). The FDI inflows for all G7 economies between years 2005 to 2020 is represent in figure 1.

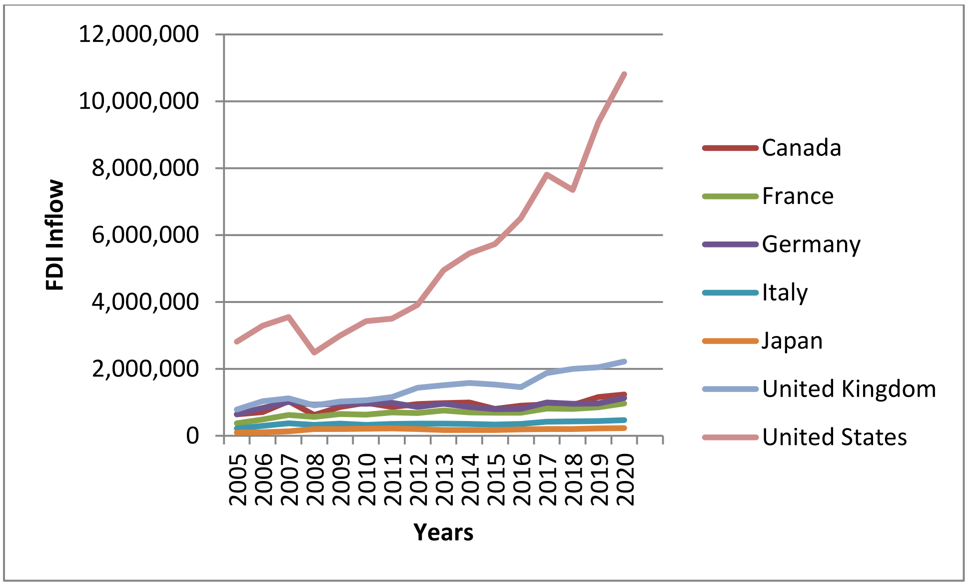


Figure 9: FDI inflow for G7 countries.

According to (Jiang et al., 2019), the theory connecting economic policy uncertainty and carbon emissions, outlined that EPU affect carbon emissions through two channels, namely; direct policy adjustment channel and indirect economic demand channel. According to the direct policy adjustment effect, amid the period of high EPU, the policy makers pay much attention to economic stabilization and give less consideration to environment protection policies. While the indirect demand effect portrays that increase in EPU distract the economic conditions and decision-making, which further increase the economic demand for energy consumption, hence, induce CO_2 emission. According to (Q. Wang et al., 2020) EPU affect carbon emission through consumption and investment. Increase in EPU decreases consumption of good and service, which further leads to decrease in energy consumption and increase environment quality. On the other hand, increase EPU decreases investment, low investment reduces energy consumption and environmental pollution. Furthermore, previous studies related to EPU reports that economic policy uncertainty affects foreign direct investment, domestic investment, international trade and GDP (Canh et al., 2020; Kang et al., 2014; Sun et al., 2020; Tam, 2018; Xu, 2020). It is also recorded in the literature that foreign direct investment, international trade, and economic growth influences CO_2 emission (Alam et al., 2021; Baloch et al., 2019; Hashmi & Alam, 2019; Omri et al., 2014; Sadorsky, 2009; Shahbaz, Hye, et al., 2013). Therefore, it is logical to ascertain that EPU affect CO_2 emission through international trade, economic growth, FDI and domestic investment.

Unfortunately, previous studies about the relationship between FDI and CO_2 emission concentrate on production-based carbon emission and ignoring the CCO_2 emission (Liddle, 2018a). Afterwards, previous researches examine the relationship between trade and CO_2 emissions but ignoring the effect of foreign direct investment inflows and outflows on consumption-base carbon emission (Hasanov et al., 2018). Recently, the study of (Gyamfi, 2021) investigate the relationship between FDI and CO_2 emissions in oil producing countries. The finding indicates that increase in FDI increases consumption-base carbon emissions.

This chapter is aimed at investigating the impact of EPU and FDI on CCO_2 emission in G7 countries for the period of 1994-2020. The basic rationale for selecting the G7 group is because of the role of the member countries in the global economic and political structure. The G7, is an organization that comprises of the world most advanced or developed countries, namely, US, UK, Canada, Italy, Germany, France and Japan, the group lack any political or legal authority, but the decisions taken at the annual G-7 summit has a significant influence on the global economy. According to the (Zucman, 2019), G7 group account for about 58% of the global wealth and about 46% of the global gross domestic product (GDP). Furthermore, the G7 countries account for 19% of the global carbon emission. It is established that all G7 countries are net importers of carbon emission (Zeeshan et al., 2021). Therefore, it is vital to examine the impact of economic policy uncertainty and foreign direct investment on consumption-based carbon emission in G7 economies.

Some studies investigated the relationship between consumption-based emissions and aggregate trade, export, import, and gross domestic products, for example(Fernández-Amador et al., 2017; Hasanov et al., 2018, 2018; Z. Khan, Ali, Jinyu, et al., 2020a; Z. Khan, Ali, Umar, et al., 2020a; Lamb et al., 2014; Liddle, 2018a). To the best of our knowledge, there is no study that specifically investigates the impact of EPU and FDI on CCO_2 in G7 countries. The current chapter will add to the literature by investigating the impact of G7 country specific EPU and FDI inflow on G-7 countries' CCO_2 emissions. The rest of the chapter is organized as follows: Review of the relevant literature is presented in the next section. Section three entails the model specification, data and methodology. Results and discussion are presented in section four. Conclusion and policy implications are presented in the last section.

4.2 Literature Review

Many studies have examined the relationship between CO2 emission, financial development, trade openness and economic growth, some of these studies includes, (Dong et al., 2016; Liddle, 2018a; Shahbaz, Mutascu, et al., 2013; Solarin, 2019; Yang et al., 2017; Zhang et al., 2014). According to (Fan et al., 2016), an increase in gross domestic product per capita enhances consumption-base carbon emissions for a panel of 14 major economies for the period of 1995 to 2009. (Adebayo et al., 2021) studied the determinant of CCO2 in Chile, for the period of 1990-2018. The outcome of the study indicates an increase in GDP enhances CCO2 emissions while an increase in renewable energy decreases CCO2 emissions. (Z. Khan, Ali, Jinyu, et al., 2020b) investigates the consumption-based carbon emissions and international trade nexus in oil exporting countries for the period of 1990-2018; they record a negative relationship between export and consumption-base carbon emissions both in the short-run and long-run. Inversely, import and gross domestic product positively impacts consumption-based carbon emissions. In a similar study (Z. Khan, Ali, Umar, et al., 2020a) examine the relationship between consumption-base emissions international trade, environment innovation and renewable energy. The outcomes of the study affirmed the existence of long-run relationship between the carbon emissions, trade, environment innovation and renewable energy, the study further records that increase in income and imports enhances consumption based conversely export, reduces the CCO2 emissions. Another study investigates the impact of financial stability, export, import, economic growth and technological innovation on CCO2 emission in E-7 (Emerging seven) economies for the period of 1995-2018. Moreover, findings reveal long-run interconnection among the variables of interest, the finding further discovered that import and economic growth increases the consumption-base carbon emission both in the long-run and the short-run, while financial stability, export and technological innovations decreases the consumption-based emission in short-run and the long-run (Safi et al., 2021).

Liddle (2018b) studied the impact of export, import, GDP, fossil fuels consumption and industrial energy intensity on both production-based and consumption-based carbon emissions for a group of Asia nations through 1990 to 2013. The findings reveal that GDP, import, export, fossil fuel consumption and industrial energy intensity positively affect production-base carbon emissions, whereas exports and industry energy intensity negative affect the consumption-base carbon emissions. In another study of (Liddle, 2018a) studied the relationship between energy prices, fossil fuel consumption, international trade, industrial value added and both production-based and consumption-based carbon emissions of a group of 102 economies spanning from 1990 to 2013. According to the findings import reduces production-based carbon emissions while export and GDP increases the production-based carbon emissions. The findings further revealed that GDP and import enhance consumption-base carbon emissions, whereas export decreases CCO2 carbon emissions. The findings also discovered that rise in energy prices decreases both production and consumption of CO2 while increase of fossil fuel consumption and industry share increases both consumption and production carbon emissions. Gross domestic production and imports positively affect the consumption-based carbon emissions while export negatively affects consumption-base carbon emissions in the oil exporting nations for the period of 1995-2013 (Hasanov et al., 2018).

We also reviewed some studies that examine the interconnection between EPU and CO2. (Adedoyin & Zakari, 2020) investigated the role of EPU on energy consumption in United Kingdom for the period of 1985-2017. The findings show that EPU enhances energy consumption. The outcomes further recorded a unidirectional causality running from carbon emissions to economic policy uncertainty and a unidirectional causal relationship running from energy use to carbon emissions, moreover a bidirectional causal relationship between real GDP and GDP per capita. (Adams et al., 2020), examined the relationship between energy consumption, EPU and CO2 emissions for the countries with high geopolitical risks for the period of 1997-2017. The outcomes reveal that GDP and energy consumption enhances CO2; the study further discovered a positive relationship between EPU and carbon emissions in the long-run. Additionally, the study recorded a two-way causality relationship between economic policy uncertainty and carbon emissions, energy consumption and carbon emission, economic growth and carbon emissions, and a one-way causality running from carbon emissions to geopolitical risk. (Pirgaip & Dinçergök, 2020), investigates the relationship between economic policy uncertainty, energy consumption and carbon emissions in G7 countries for the period of 1998-2018, by applying the bootstrap panels granger causality analysis, the findings suggests a one-way causality running from economic policy uncertainty to carbon emissions in US and Germany; from economic policy uncertainty to carbon emissions and energy consumption in Canada; and from economic policy uncertainty to energy consumption in Japan. The study further discovered a one-way causal relationship running from CO_2 emissions to EPU, whereas a two-ways causal relationship exists between energy consumption and EPU. Moreover, the study recorded a one-way causal relationship from energy consumption to carbon emissions.

(Adedoyin et al., 2021) studied the role of EPU in the generation of energy in African nations for the period of 1996-2014. According to the findings the generation of non-renewable energy and gross domestic product enhances carbon emissions. The findings further discovered EPU as a moderating variable for renewable and non-renewable energy generation decreases carbon emissions in Sub-Saharan Africa. (Anser et al., 2021) examined the impact of EPU on CO_2 emissions for a panel of the top ten carbon discharging nations. The outcomes indicate that EPU has a positive impact on CO_2 emissions both in the short-run and the long-run. Another study examines the impact of energy consumption and economic policy uncertainty on CO_2 emissions a case study of China for the period of 1970-2018. The findings of the study revealed that energy use and GDP has a positive impact on CO_2 emissions in both short-run and the long-run. The study further documents a statistical insignificant effect of economic policy uncertainty on CO_2 emissions (Lei et al., 2022). (Q. Wang et al., 2020) examine the effect of economic policy uncertainty on carbon emission in United States for the period of 1960-2016. The study records a positive association between economic policy uncertainty and carbon emissions in the long-run; similarly, the study records a positive relationship between per capita income and carbon emissions in the long-run. The study further records a negative association between energy price and CO_2 emissions in the long-run. In another study, (Y. Khan et al., 2022) studied EPU and CO_2 emission in East

Asian nations over the period of 1997-2020, the study documents a positive relationship between EPU and CO2 emission. (Nakhli et al., 2022) discovered a bidirectional causality relationship between economic policy uncertainty and carbon emission. According to the findings of (Chu & Le, 2022) , high economic policy uncertainty decreases carbon emission.

Only the study of (Gyamfi, 2021) specifically examine the interconnection between FDI and CCO2 emission for a bloc of oil producing economies between 1990 to 2018. The findings indicate that increase in FDI increases consumption-based CO2 emissions. Therefore, we review some previous studies in the literature about the relationship between foreign direct investment and carbon emission. According to (Y. Khan et al., 2022), economic policy uncertainty, trade and GDP has positive effect on carbon emission, while foreign direct investment and renewable energy reduces carbon emission in East Asian economies. (Blanco et al., 2013) Investigate the relationship between foreign direct investment and carbon emissions for 18 South American economies spanning from 1980 to 2007, the findings of the study revealed a positive relationship between foreign direct investment and carbon emission. (Haug & Ucal, 2019), studied the relationship between foreign direct investment and trade on CO2 emission in Turkey, the findings revealed a positive relationship between FDI and carbon emission. Hence an increase in FDI enhances carbon emission. In a similar study (Gökmenoğlu & Taspinar, 2016) discovered a positive correlation between foreign direct investment and CO2 emission in Turkey the period of 1974-2010. (Omri et al., 2014) Examine the causality relationship between foreign direct investment and carbon emission for a panel of 54 countries over the period of 1990-2011. The result of the study revealed bidirectional causality between foreign direct investment and carbon emission. (Bukhari et al., 2014) studied the effect of FDI on CO2 emission for Pakistan. The findings of the study record a positive relationship between FDI and CO2. (Lin et al., 2022) Investigate the role of foreign direct investment on carbon emission reduction in china. The findings of the study indicate a positive correlation between FDI and CO2 emissions

4.3 Data, Model Specification and Methodology

The current study employs annual time series data for the period of 1994-2020 for G7 economies. The selection of the time span is based on availability and reliability of the data. The data for consumption-base carbon emissions (CCO2) per capita is obtained from OECD website. The data for economic policy uncertainty (EPU) is source from (Economic *Policy Uncertainty Index*, n.d.). Foreign Direct Investment (FDI) and t control variables namely, Foreign Portfolio Investment (FPI), Domestic Investment (DI) and Gross Domestic Product per capita (GDP) are obtained from (World Development Indicators | DataBank, n.d.).

Below is the general model specification:

$$CCO2it = f(EPUit, FDIit, PIit, DITit, GDPit) \quad (25)$$

In the equation above “i” represent the cross-section of the countries included in the study, i.e. Canada, France, Germany, Italy, Japan, UK and USA. While, “t" represent the time period of the study i.e. 1994-2020. Below is the econometrics model specification:

$$CCO2it = \alpha 0 + \alpha 1 lnEPUit + \alpha 2\, lnFDIit + \alpha 3 lnPIit + \alpha 4 ln\, DIit + \alpha 5 lnGDPit + \mu it$$

(27)

Where; $CCO2it$ represent consumption -base carbon emission per capital, which is measured as total fossil fuel emission plus import minus export per unit of metric tons of carbon emission divided by the total population. $EPUit$ Stand for country specific economic policy uncertainty index. $FDIit$, Stands for FDI inflows per capital, which represents the total inflow direct investment done by foreign investors within a country divided by the total population. $FPIit$, denotes foreign portfolio investment per capita, which is measured as the inflow of financial investment by foreigner in a given country divided by the total population. $DIit$ Stands for domestic investment by the citizens of a country, divide by the total population. $GDPit$, is the gross domestic product per capita; it is defined as the total production of good and services within a country divided by the total population. The symbol α_0 is the intercept parameter; α_1, α_2, α_3, α_4 and α_5 are the slope coefficient and μit are the error term.

According to the theory and previous studies (Alam et al., 2021; Baloch et al., 2019; Canh et al., 2020; Hashmi & Alam, 2019; Jiang et al., 2019; Kang et al., 2014; Omri et al., 2014; Sadorsky, 2009; Shahbaz, Hye, et al., 2013; Sun et al., 2020; Q. Wang et al., 2020; Xu, 2020) EPU has a negative relationship with consumption-based carbon emission. Hence, economic policy uncertainty is expected to have a negative sign. According to the recent study of (Gyamfi, 2021) foreign direct investment is positively related consumption-based carbon emission. Therefore, we expect the FDI to have a positive sign. For our control variables, we are expecting domestic investment and gross domestic product per capita are expected to have positive signs, while portfolio investment is expected to have a negative sign.

4.3.1 Methodology

Globalization has increase interconnectedness and interdependent among countries, thus a shock in one of the series in one of the G7 member may affect other members via diverse channels. Therefore, there is high tendency to have cross-sectional dependency (CD) and slope heterogeneity among G7 members. Hence, for successful estimations of panel regression is vital to conduct a cross-sectional dependency and slope heterogeneity among the panel members, the CD test will enable us to make the right choice of the generation of panel data technique to apply. Disregarding the CD test may lead to bias and spurious regression. Therefore, we start our analytical frame work by employing the (Pesaran, 2004b) and the (Breusch & Pagan, 1980) Lagrange multiplier (LM) CD test. Below is the equation for Pesaran 2004 CD tests:

$$CD = \sqrt{\frac{2W}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} (W-K) \frac{\hat{\rho}_{ij}^2 - E(W-K)\hat{\rho}_{ij}^2}{\sigma^2 \, (W-K)\hat{\rho}_{ij}^2} \tag{28}$$

Where $\hat{\rho}_{ij}^2$ is the expected correlation coefficient extracted from the residuals of the ordinary least square regression, below is the specification of the Breusch and Pagan 1980 LM test:

$$LM = T_{ij} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij}^2 \rightarrow x^2 \; \frac{N(N-1)}{2} \tag{29}$$

Where; N and T are number of cross-sections and years respectively.

We further employ slope heterogeneity test proposed by (Pesaran & Yamagata, 2008) which accounts for cross-sectional dependency (S. A. R. Khan, Yu, Belhadi, et al., 2020). Below are the equations for slope heterogeneity test:

$$\widetilde{\Delta_{JW}} = \left(\sqrt{N}\right)\left(\frac{1}{2\left(\sqrt{k}\right)}\right)\left(N^{-\frac{1}{2}}\breve{w} - k\right) \tag{30}$$

$$\widetilde{\Delta_{AJW}} = \left(\sqrt{N}\right)\left(\frac{1}{\sqrt{\frac{2k(T-k-1)}{T+1}}}\right)\left(\left(N^{-1}\right)\breve{w} - 2k\right) \tag{31}$$

Where, delta tilde is presented in equation 29 and adjusted delta tilde is represented in equation 30.

The first generation panel unit root test such as (Levin et al., 2002) and (Im & Pesaran, 2003) assumes cross-sectional independency among the series, the first generation panel unit does not adjust for cross-sectional dependency problem. Hence the current study employs the second generation panel unit to control for cross-sectional dependency problem. Therefore, we apply CADF and CIPS unit root methods to confirm the unit root and stationary of our series. Equations 31 and 32 represent the equations for CADF and CIPS respectively.

$$\Delta x_{it} = \partial_{1i} + \partial_2 x_{i,t-1} + \partial_3 \bar{x}_{t-1} + \sum_{j=0}^{s} \partial_{4ij} \Delta\bar{x}_{t-j} + \sum_{j=1}^{s} \partial_{5ij} \Delta\bar{x}_{i,t-1} + \epsilon_{it} \quad (32)$$

$$cips = M^{-1} \sum_{i=1}^{M} cadf_i \quad (33)$$

The conventional panel data cointergration test such as Pedroni 1999 (Pedroni, 1999) residual-based panel cointegration technique does not adjust for cross-sectional dependency among our series (Kapetanios et al., 2014). Therefore, to check for the existence of long-run relationship between consumption-base carbon emission, economic policy uncertainty, foreign direct investment, portfolio investment, domestic investment and gross domestic product per capita, we apply (Westerlund, 2007) cointergration test technique, this method is efficient and effective as it adjust for mix order integrated series, cross-sectional dependency and heterogeneity slope. Equation 33 represents the error correction model:

$$\Delta x_{it} = \theta_i' d_t + \varphi_i\left(x_{i,t-1} - \emptyset_i' z_{i,t-1}\right) + \sum_{j=1}^{p_i} \varphi_{ij}\, \Delta x_{i,t-1} + \sum_{-qi}^{p_i} \vartheta_{ij}\, \Delta z_{i,t-j} + \epsilon_{it} \quad (34)$$

Where d_t stands for deterministic elements, $p_{i\mathrm{I}}$ represents the lag length and qi stands for leads orders, $p_{i\mathrm{i}}$ and qi are allowed to vary between individual cross-sections. Equations 34 and 35 are for two group-mean analysis statistics, while equations 36 and 37 are the two panel analysis statistics under the Westerlund (2007):

$$G_\tau = \frac{1}{N}\sum_{i=1}^{N}\frac{\emptyset_i}{SE(\emptyset_i)} \quad (35)$$

$$G_\alpha = \frac{1}{N}\sum_{i=1}^{N}\frac{T\emptyset_i}{\emptyset_i(1)} \quad (36)$$

$$P_\tau = \frac{\emptyset_i}{SE(\emptyset_i)} \quad (37)$$

$$P_\alpha = T\emptyset_. \quad (38)$$

The Westerlund cointergration H0≠cointegration and H1=cointegration. Since the current chapter is employing the ARDL model, cointegration test is not needed. The current chapter employs ARDL technique to investigate both long term and short term dynamics between CCO2 emissions, EPU, FDI, portfolio investment, domestic investment and gross domestic product per capita for G7 countries. We apply the pooled mean group estimator (PMG) method proposed by (Pesaran et al., 1999). The panel ARDL model is applicable even if the series follow a diverse order of integration of the series i.e. l(0) and l(1) or combination of the two (Pesaran & Smith, 1995b). The advantage of the PMG model is that it combines the features of the mean group (MG) method (includes the intercept, short-run coefficient and disparate error variance among the cross- section) and the features of dynamic fixed effect (DFE) method (holding long-run coefficient across the cross-sections). Cross-sectional dependency and heterogeneity are the problems that the traditional approach does not address (Yao et al., 2019). Hence, we use the panel ARDL technique to investigate the long-run and short-run relationship between our dependent variable and the explanatory and control variables. Furthermore, we apply Augmented Mean Group (AMG) estimators proposed by (Eberhardt, 2012)and the Common Correlated Effects Mean Group (CCFMG) estimator proposed by (Pesaran, 2006) for robustness check. The selections of the above mentioned models are that, both model deal with the problem of slope heterogeneity and cross-sectional dependency. Below is the equation for panel ARDL model:

$$CCO2_{it} = \alpha_{it} + \sum_{l=1}^{r} \alpha_1 lnCCO2_{it-l} \sum_{l=0}^{r} \alpha_2 lnEPU_{it-l} + \sum_{l=0}^{q} \alpha_3 lnFDI_{it-j} + \sum_{l=0}^{q} \alpha_4 lnFPI_{it-j} + \sum_{l=0}^{q} \alpha_6 lnDI_{it-j} + \sum_{l-0}^{q} \alpha_5 lnGDP_{it-j} + \mu_{1it} \quad (39)$$

Where l stands for country index and t stands for time index. The equation developed into the equation below after parameterization:

$$\Delta lnCCO22_{li} = \alpha_{it} + \emptyset_{il} \left(lnCCO2_{il-l} - \varphi_1 lnEPU_{il-l} \varphi_2 lnFDI_{il-l} - \varphi_3 lnPI_{il-l} - \varphi_4 lnDI_{il-l} - \varphi_5 \ lnGDP_{il-l}\right) \sum_{l=1}^{p-1} \gamma_{1il} \Delta CCO2_{it-l} + \sum_{l=0}^{q-1} y'_{1il} \Delta lnEPU_{it-l} + \sum_{l=0}^{q-1} y''_{1il} \Delta lnFDI_{it-l} + \sum_{l=0}^{q-1} y'''_{1il} \Delta lnPI_{it-l} + \sum_{l=0}^{q-1} y''''_{1il} \Delta lnDI_{it-l} + \sum_{l-0}^{q-1} y'''''_{1il} GDP_{it-l} + \mu_{1it} \quad (40)$$

Where,$\gamma, \gamma', \gamma'' \ \gamma''', \gamma'''', \gamma'''''$ are the short-run parameters for lagged dependent variable and explanatory variables, the coefficients $\varphi_1, \varphi_2, \varphi_3, \varphi_4$ and φ_5 represents long run coefficient for independent variables, $\emptyset_{il}$ is the speed of adjustment.

4.5 Results

The summary of the descriptive statistics of natural logarithm of our variables of interest is recorded in table 12; the average of the consumption-based carbon emissions is 6.878910 with maximum and minimum values are 8.796033 and 6.077431 respectively. EPU has an average of 7.253614, 6.112000 and 8.781584 are the minimum and the maximum values respectively. The mean of FDI is 24.18367, 10.029 is the maximum value and 17.36803 is the minimum value. The maximum value for PI is 10.57395, the minimum value is 16.34694 and the mean is 13.93712. The mean of DI is 13.58148, the minimum value is 10.95538 and the maximum value is 16.00088. The average gross domestic product per capita is 10.37676, with 11.04762 and 9.723065 as maximum and minimum values respectively. The skewness of foreign direct investment, portfolio investment, domestic investment are negative, while CCO2 emissions and EPU product has a positive skewness. The kurtosis of consumption-based carbon emissions, economic policy uncertainty and foreign direct investment are heavily-tailed, while portfolio investment, domestic investment and gross domestic product per capita have light-tailed kurtosis. The probability values of the Jarque-Bera statistics shows that CCO2, EPU, FDI and portfolio investment are not normally distributed, while domestic investment and gross domestic product are normally distributed. Table 2 reports the outcome of the correlation matrix, which indicates CCO2 has a negative correlation EPU and portfolio investment, while FDI, domestic investment and gross domestic product per capita has a positive correlation with CCO2 emissions.

Table 12: Descriptive statistics

	lncco2	lnepu	lnfdi	lnfpi	Lndi	lngdp
Mean	6.878910	7.253614	24.18367	13.93712	13.58148	10.3767
Median	6.479599	7.223525	24.26322	14.09884	13.68753	10.4281
Maximum	8.796033	8.781584	26.96048	16.34694	16.00088	11.0476
Minimum	6.077431	6.112000	17.36803	10.57395	10.95538	9.72307
Std. Dev.	0.842680	0.423168	1.418380	1.220059	1.102551	0.30117
Skewness	1.332448	0.713795	-0.820049	-0.608659	-0.138793	-0.17285
Kurtosis	3.388672	4.051656	5.295017	2.835953	2.452459	2.22688
Jarque-Bera	56.51091	24.49695	61.99847	11.75587	2.936327	5.58841
Probability	0.000000	0.000005	0.000000	0.002801	0.230348	0.06117
Sum	1286.356	1356.426	4522.346	2606.241	2539.737	1940.45
Sum Sq.D	132.0803	33.30720	374.1952	276.8692	226.1053	16.8704
Observations	187	187	187	187	187	187

Table 13: Correlation matrix

correlation	lncco2	lnepu	lnfdi	lnpi	lndi	lngdp
lncco2	1.000000					
lnepu	-0.143415	1.000000				
lnfdi	0.428390	0.092591	1.000000			
lnfpi	-0.469970	0.284893	0.571219	1.000000		
lndi	0.522980	0.321029	0.721911	0.880619	1.000000	
lngdp	0.313001	0.443591	0.513848	0.822993	0.857178	1.0000

The first generation unit root tests and cointegration tests do not deal with CSD problem. Hence, working with the first generation panel may likely leads to bias estimations. The result of cross-sectional dependency test is reported in table 14, which signifies the existence of cross-sectional dependency between the G7 member countries; hence, an economic shock in one country can have an effect on other countries. Therefore, the second generation unit roots tests and cointergration is more appropriate for the current study. We further detect the problem of slope heterogeneity from the outcome of the Pesaran and Yamagata 2008 slope heterogeneity test, which is reported in table 4.

Table 14: Cross-sectional dependency test

Test	Statistic	d.f.	Prob.
Breusch-Pagan LM	205.3103	21	0.0000
Pesaran scaled LM	28.43969		0.0000
Pesaran CD	12.83546		0.0000

*** signifies a 5% significant level

Table 15: Slope heterogeneity test

Slope Heterogeneity Test	Statistic	Prob.
Delta tilde	8.450***	0.0000
Adjusted Delta tilde	6.691***	0.0000

*** signifies a 5% significant level

The results of the second generation panel unit root test are recorded in table 16, according to the results of cross-sectional Im, Pesaran and Shin (CIPS) and the cross-sectional augmented Dickey-Fuller (CADF) panel unit root tests; consumption-base carbon emissions, economic policy uncertainty, foreign direct investment, portfolio investment, domestic investment and gross domestic product per capita are non-stationary at levels. After taking the first difference, all the variables became stationary. Therefore we conclude that our variables are integrated of order one or l(1). Hence, we can proceed to Westerlund cointegration test.

Table 16: Stationarity tests

Variables	IPS	ADF
	Level	Levek
lnCCO2	0.9319	0.6968
lnEPU	-0.96229	19.6543
lnFDI	-1.39133	22.6153
lnFPI	-1.92675	22.1844
lnDI	-0.62128	18.3125
lnGDP	1.27116	7.73686
	First Difference	First Difference
lnCCO2	-7.44468***	78.779***
lnEPU	-7.95407***	84.009***
lnFDI	-7.86607***	82.567***

lnIPI	-5.03159***	53.305***
lnDI	-4.37530	46.991***
lnGDP	-7.07195***	74.751***

*** represents a 5% significant level

According to the outcome of the Westerlund Panel cointegration test, we discovered the existence of long-run association between consumption-base carbon emissions, economic policy uncertainty, foreign direct investment, portfolio investment, domestic investment and gross domestic product per capita. Since this chapter is using panel ARDL estimators, hence, is not necessary to conduct the cointegration test.

Table 17: Westerlund penal cointegration test

Statistic	Value	P-value
G_τ	-0.318***	0.0000
G_α	-0.271***	0.0000
P_τ	-0.837***	0.0000
P_α	-0.291 ***	0.0025

*** represents a 5% significant level

The main findings of this chapter are reported in table 18. Our entire variables are in per capita excluding economic policy uncertainty which is an index. We start with economic policy uncertainty, according to the result of our estimations, holding all other variable constant a 1% increase in EPU reduces the CCO2 emission by 2.32% on average in the long-run, economic policy uncertainty is also statistically significant in the long-run. This finding requires an economic explanation; as mentioned earlier in this chapter international trade, GDP, FDI, energy domestic investment are the channels through which the G7 countries' specific EPU affect G7 countries consumption-base carbon emission, hence, EPU indirectly affect CCO2. Therefore, an increase in EPU denotes decrease in international trade, foreign direct investment, domestic investment, portfolio investment and economic growth (Canh et al., 2020; Kang et al., 2014; Z. Khan, Ali, Umar, et al., 2020a; Lau & Tan, 2014, 2014; Pesaran, 2006; Seker et al., 2015; Tam, 2018; Q. Wang et al., 2020). Hence, decline in G7 countries' international trade, foreign direct investment, domestic investment, portfolio investment and economic growth decreases G7 countries' consumption-base carbon emission. Hence, our findings are in line with the literature.

The outcomes further revealed a positive and significant impact of foreign direct investment inflows on CCO2. In ceteris paribus, 1% average increase of foreign direct investment inflows increases CCO2 emission by 0.94%. The findings about foreign direct investment inflows is in consistent with the theory, which suggest that an increase in FDI inflow results to an increase in production and consumption of the goods and services in the host countries, which further leads to increase in energy consumption. Therefore, foreign direct investment increases consumption-based carbon emission in G7 countries. The findings are similar to that of of (Gyamfi, 2021). The effect of domestic investment on consumption-based carbon emission is very similar to that of the foreign direct invest. According to our findings 1% average increase in domestic is associated with 1.69% increase in CCO2 emissions; domestic investment is also statistically significant. Unlike foreign direct investment and domestic investment, portfolio has a negative sign as expected. The coefficient of foreign portfolio is statistically significant; a one percent raise in foreign portfolio denotes 0. 31% average decrease of consumption-base carbon emissions.

The chapter further discovered a positive and significant relationship between gross domestic product per capita and consumption-based carbon emission based on the outcomes a 1% average improve of GDPPC is associated by 6.04% increase in CCO2 emission. Both private and government consumption are component of GDP, hence, more consumption enhances consumption-base carbon emissions (Lau & Tan, 2014; Seker et al., 2015). Furthermore, general increase in income raises government and household consumption, which results to increase in CO2 emissions (Hasanov et al., 2018; Z. Khan, Ali, Umar, et al., 2020b). As mention in this chapter, foreign direct investment, domestic invest and economic growth are among the channels through which economic policy uncertainty influences consumption-based carbon emission. Therefore, the findings regarding foreign direct investment, domestic invest and economic growths are similar to the literature and the theory.

Economic policy uncertainty and portfolio investment inflow negatively impact consumption-base carbon emission in the short-run. Moreover, the coefficients of EPU (-0.21) is statistically significant in the short run, while PI (-0.25) is statistically insignificant in the short-run. FDI, DI and GDP are positively interconnected with CCO2 emissions in the short-run and their coefficients 0.86, 0.83 and 0.66 respectively. The coefficient of FDI is statistically significant in the short run, while the coefficients of DI and GDP are statistically insignificant in the short run. Therefore, the signs for our variables are the same in both short-run and long-run. Finally the Error Correction Model (ECM (-1)) which is 0.24 % indicates the speed of adjustment from the short run disequilibrium to adjustment to their long-run equilibrium.

Table 18: Autoregressive distributive lag model (PMG)

Dependent Variable: lnCCO2			
Variables	Short-Run	Variables	Long-Run
lnEPU	-.021154*** (.0104152) { 0.001}	lnEPU	-2.32306*** (.0209816) {0.000}
lnFDI	.085484*** (0.005195) {0.000}	lnFDI	.9419585*** (.0102636) { 0.0000}
lnPI	-.025449*** (.0306353) {0.142}	lnPI	-.313827*** (.0149434) { 0.0000}
lnDI	.082924*** (.0258043) {0.000}	lnDI	1.689959 (.0036824) { 0.000)
lnGDP	.6607063*** (.1322808) { 0.000}	lnGDP	6.041413*** (.0808302) { 0.000)
ECM(-1)	-.2443291 (0.0001)		

*** stands for 5% significance level, ** stands for 10% Significance level, * stands for1% significance level. Values in the () represents the standard errors and Numbers in {} are the p-values

The results for robustness check are reported in table 19; we applied the augmented mean group (AMG) and the common correlated effect mean group (CCEMG). The outcome of AMG and CCEMG confirms an increase in economic policy uncertainty decreases consumption-base carbon emission with coefficients -0.01 and -0.11

respectively. The findings further validate a positive effect of foreign direct investment and domestic investment on consumption-base carbon emissions with coefficients 0.64 (AMG), 0.10 (CCEMG) and 0.10 (AMG), 0.64(CCEMG) respectively. Similarly, an increase in gross domestic product enhances consumption-base emission with coefficient 0.36 and 0.56 in AMG and CCEMG respectively. Conversely a negative impact of foreign portfolio investment on consumption-base carbon emission in AGM and CCEMG models, with coefficients -0.03 and -0.13 respectively. Therefore, our results from the robustness analysis affirms the outcome of our panel ARDL mode.l

Table 19: Robustness check

Variables	**AMG**	**CCEMG**
lnEPU	-.0135727***	-.011389
	(.008456)	(.0195894)
	{ 0.004}	{0.565}
lnFDI	.642005***	.101183***
	(.004326)	(.0042261)
	{0.000}	{0.202}
lnPI	-.031722***	-.133395***
	(.0164329)	(.0565434)
	{ 0.000}	{0.018}
lnDI	.0107029	.634806***
	(.019271)	(.0328092)
	{0.693}	{ 0.000}
lnGDP	.3604755***	.0551294***
	(.0960825)	(.1466796)
	{ 0.000}	{ 0.000)
Wald chi2(5)	15.73	8.40

***, **, * denotes 5%, 10% and 1% significance level, respectively.
Numbers in () are the standard errors and numbers in {} are the p-values.

Finally, the results of pairwise Dumitrescu Hurlin panel causality test are reported in table 20. According to the findings there is bidirectional causality between consumption-based carbon emissions and economic policy uncertainty. Hence, G7 countries economic policy uncertainty is an important predictor of G7 countries consumption-base carbon emissions; likewise, G7 countries consumption-based carbon emission is an important predictor of G7 Countries economic policy uncertainty. This chapter discovered the same relationship between foreign direct investment and gross domestic product per capita. Hence, foreign direct investment and gross domestic product per capita are important predictors of each other. Bidirectional causality also exist between foreign direct investment and domestic investment, the same relationship exist between foreign direct investment and foreign portfolio investment. Similarly, the chapter discovered two-ways causality between gross domestic product per capita and foreign portfolio investment inflows.

The chapter further discovered unidirectional causality running from foreign portfolio investment to consumption-base carbon emission; therefore, foreign portfolio investment is an important predictor of consumption-base carbon emission. Similarly, we record a one-way causal relationship moving from GDPPC to CCO2 emission; thus, GDP per capita is an important predictor of consumption-base carbon emission. Moreover, we detect a unidirectional causality from foreign direct investment to economic policy uncertainty, the same relationship exist from economic policy uncertainty to foreign portfolio investment. Furthermore, the findings reveal a unidirectional causality from gross domestic product per capita to foreign direct investment, hence, gross domestic product per capita is and important predictor of foreign direct investment. Lastly, the chapter discovered a unidirectional causality from GDPPC to DI.

Table 20: Pairwise Dumitrescu Hurlin panel causality tests

Economic Policy Uncertainty	↔	Consumption-base Carbon Emissions
Portfolio Investment	→	Consumption-base Carbon Emissions
Gross Domestic Product Per Capita	→	Consumption-base Carbon Emissions
Foreign Direct Investment	→	Economic Policy Uncertainty
Economic Policy Uncertainty	→	Portfolio Investment
Portfolio Investment	↔	Foreign Direct Investment
Domestic Investment	↔	Foreign Direct Investment
Gross Domestic Product Per Capita	↔	Foreign Direct Investment
Portfolio Investment	→	Domestic Investment
Gross Domestic Product Per Capita	↔	Portfolio Investment

↔represent bidirectional causality and → represent unidirectional causality

4.5 Conclusion

This chapter investigates the impact of EPU and FDI on CCO2 emissions for G7 economies, for the span of 1994-2020. The chapter applied the panel Autoregressive Distributive Lag Model (ARDL). The findings revealed a negative and significant short-run relationship between economic policy uncertainty and consumption-base carbon emission. Moreover, the findings discovered a positive and significant relationship between foreign direct investment and consumption-base carbon emission in the short-run. The findings further recorded a positive and significant association between domestic investment and consumption-base carbon emission in the short-run. Gross domestic product per capita also has a positive and insignificant effect on consumption base carbon emission in the short-run. According to the findings, consumption-base emissions, economic policy uncertainty, foreign direct investment inflow, portfolio investment, domestic investment and gross domestic product per capita are moving from the short-run disequilibrium to long-run equilibrium at a speed of 0.25% (ECM). Our findings further record an increase in economic policy uncertainty and portfolio investment decreases consumption-based carbon emissions in the long-run. Conversely, foreign direct investment, domestic investment, gross domestic product per capita intensifies consumption-base carbon emission in the long-run. The robustness check from AMG and CCEMG support the findings. The outcome of pairwise Dumitrescu Hurlin causality analysis documents two-ways causality between EPU and CCO2 emission.

The findings for foreign direct investment, portfolio investment, domestic investment and gross domestic product per capita are consistent with the theory and empirical literature. The findings about the relationship between economic policy uncertainty and consumption-base carbon emission are the contributions of this study to the literature. Therefore, an increase G7 countries economic policy uncertainty reduces consumption-base carbon emission in in the countries. Moreover G7 EPU can be used as a predictor for CCO2 emissions in G7 countries. Considering the role of the global carbon emissions in climate change; hence the current chapter suggest that in order to decrease the impact of foreign direct investment, domestic investment and gross domestic product per capita on consumption-base carbon in G7 countries, the countries should encourage more of environmental friendly foreign direct investment, domestic investment and domestic product and consumption of goods and services, they should also discourage energy intensive foreign direct investment, and domestic investment. Policy makers should also replace domestic production and consumption of energy intensive products with environment friendly products.

Chapter 5

CONCLUSION AND POLICY IMPLICATIONS

5.1 Conclusion

This thesis investigates the impact of economic policy on certainty on energy prices, financial stability and consumption-based carbon emissions. The second chapter of this thesis investigates the interconnection between economic policy uncertainty and energy prices in Russia by applying DCC-MGARCH models. Energy sector is crucial to Russian economy; therefore natural gas and crude oil prices are very important to Russia. Hence is vital to investigate the relationship between Russia EPU index and energy prices. Since EPU and energy prices are volatile variables, the chapter applied volatility models to examine the interdependent between the variables of interest. The findings of the second chapter indicate the existence of interconnection between the energy prices and REPU index, the results further revealed that a shock on natural gas supply last longer than the same effect on crude oil supply. Furthermore, the outcomes recorded a co-movement of natural gas and crude prices on REPU index; moreover, the conditional correlation between natural gas prices and EPU is higher than that of between crude oil price and EPU. The findings of this chapter clearly indicate that REPU has more co-movement with natural gas price than crude oil price. This results is not surprising considering the role of Russia in natural gas market, Russia is the second largest producer and the largest exporter of natural gas in the world. The chapter further discovered that the correlation between REPU and natural gas prices and the correlation between EPU and crude oil prices follows the same pattern. They both increased and declined at the same period. Furthermore, the study revealed that crucial global events like global financial crisis, September 11 terrorist attack and Russia financial crisis are important factors that determine the interconnection REPU and energy prices.

The third chapter examined the impact of USA economic policy uncertainty on BRICS countries financial stability using MG, AMG, CCFMG models. US remains the strongest economy in the world, therefore, the US EPU index is crucial to many countries, more especially the BRICS countries. The findings of the chapter discovered a long-run relationship between USA economic policy uncertainty, BRICS financial stability, trade openness, exchange rates, inflation, gross domestic product per capital, domestic credit to private sector and gross capital formation. The annual speed of adjustment of the variables from short-run disequilibrium to the long is 17%. The empirical findings of the study revealed that a rise in US EPU index enhance BRICS financial instability. Moreover, the findings revealed that an increase in trade openness, gross domestic credit per capital and gross capital formation improves BRICS financial stability. Conversely, exchange rate, inflation rate and domestic credit to private sector distract BRICS financial stability. Furthermore, the finding of chapter three shows that financial stability is an important predictor of GDPPC, gross capital formation and exchange rate.

The fourth chapter investigates the influence of G7 EPU index and FDI on consumption-based carbon emissions by employing the second generation panel ARDL model. The short-run findings of the chapter indicate that an increase in G7 EPU index decreases consumption-based carbon emissions. Conversely, FDI positively influences consumption-based carbon emission. The short-run results findings of the chapter also record a positive effect of domestic investment and gross domestic product per capital on consumption-base carbon emissions. While, portfolio investment has a negative effect on CCO2. The speed of the adjustment of the variables from short-run to the long-run path is 0.25% annually. The long-run findings indicate that an increase in G7 EPU and portfolio investment decreases CCO2. Contrarily, the long-run outcomes indicate that an increase in FDI, domestic investment and gross domestic product per capital improves CCO2. The findings of the chapter further recorded two ways causality between G7 EPU index and CCO2.

5.2 Policy Implications

The findings of the three chapters` included in this thesis have policy implications as follows:

1. Russian policy makers should initiate the process of switching to more environment friendly economy, such as renewable energy and green economy; this will improve environment quality, enhance trade and increase economy stability. This will further reduce the over reliance of Russian economy on energy sector.
2. The policy makers of all BRICS countries should not pay much attention to US EPU; they should rather pay attention to their country specific EPU index and immediate response to EPU shock with good fiscal or monetary policies that will stabilize the financial system.
3. Finally, the policy makers of G7 countries should encourage, importing, domestic product and consumption of more environment friendly goods and services. And discourage consumption, production and importing of energy intensity products. This will not only improve environment quality, it will

also improve trade with the rest of the world as all other countries are transiting to trade of less energy intensity product.

Research on the interconnections between economic policy uncertainty and financial stability is vast, developing and increasing. Therefore, the current thesis creates some areas for future research. Despite the fact that, BRICS countries have different characteristics, different financial and economic system and different leadership style. Therefore, the above mentioned individual characteristics of BRICS countries need to be captured in the study of the relationship between US EPU and BRICS economies financial stability. Future studies can investigate the impact of US EPU on individual BRICS countries' financial stability.

Secondly, the consumption-based carbon is a new discovery, with no specific theory that is linking it to EPU; the individual country impact is not captured in this thesis. Therefore, the relationship between EPU and G7 consumption-based carbon emissions can be studied for each G7 country separately. Even though, G7 countries have many similar characteristics, but each of them has some peculiarities that needed to be included in the study of the impact of economic policy uncertainty on consumption base carbon emissions.

Finally, there could be omission variable bias because of the estimation of the models with EPU and energy prices, EPU and financial stability and EPU and consumption-based carbon emissions are analyzed separately. Hence, future researches may include more variables to each model. This can solve the problem of omission variable bias (if any) and further verify the findings of this thesis.

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