AMERICAN UNIVERSITY OF BEIRUT

THE EFFECTS OF UNCERTAINTY AND FINANCIAL DEVELOPMENT ON RENEWABLE ENERGY CONSUMPTION IN OIL-IMPORITNG AND EXPORTING MENA COUNTRIES: A NON-LINEAR AUTOREGRESSIVE DISTRIBUTED LAGS APPROACH

by
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ABSTRACT
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Title: The Effects of Uncertainty and Financial Development on Renewable Energy Consumption in Oil-Importing and Exporting MENA Countries: A Non-Linear Autoregressive Distributed Lags Approach

The Relationship between Financial development and Economic growth is intrinsic. It has been shown in Literature that Economic growth leads to financial development and vice versa, however, a more interesting relation that is being discussed between environmental scientists, economists and policy makers is that of Financial development and Energy consumption, in specific renewable energy consumption. We used a pooled mean group (PMG) panel nonlinear autoregressive distributed lags (NARDL) model to investigate the influence of uncertainty and financial development on renewable energy consumption in 18 MENA countries (divided into importing and exporting countries with 9 countries for each) from 1990-2020. The model takes advantage of using the broad based financial development measure developed by Svirydzenka (2016) which compresses the various elements of financial development into an index that comprises both financial markets and financial institutions into 3 distinct themes namely; (access, depth and efficiency). In the Long run, results show that a positive shock to uncertainty leads to a negative effect in renewable energy consumption in both importing and exporting countries, however a negative shock to uncertainty negatively affects renewable consumption in exporting countries without having any effect on oil importing countries. Results also show that Financial development negatively affects renewable energy consumption in oil importing countries while having no effect in oil exporting countries. In the short run, a positive shock to uncertainty has a positive and significant effect on renewable consumption in oil importing countries but no effect in oil exporting countries, whereas a negative shock has no effect in both. The results also show that financial development has a significant positive effect in importing countries but no effect in exporting countries. Moreover, we employed the Pairwise Dumitrescu–Hurlin panel causality tests to study the existence and direction of causality among variables. The causality test results display that uncertainty has a unidirectional causality with renewable energy consumption in both oil importing and exporting countries, while financial development has a bidirectional causality in oil importing countries and no causality in oil exporting countries. Finally, a DOLS model was employed as a robustness test to account for omitted variables.

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ABBREVIATIONS

EC (Energy consumption)

REC (Renewable energy consumption)

Y (Gross domestic product 2015PPP)

PMG (Panel mean group)

ARDL (Autoregressive distributed lags)

DOLS (Dynamic Ordinary least squares)

RGP (Retail Gasoline price)

ROP (Real Oil price)

WUI (World Uncertainty Index)

MENA (Middle East and North Africa)

CHAPTER I

INTRODUCTION

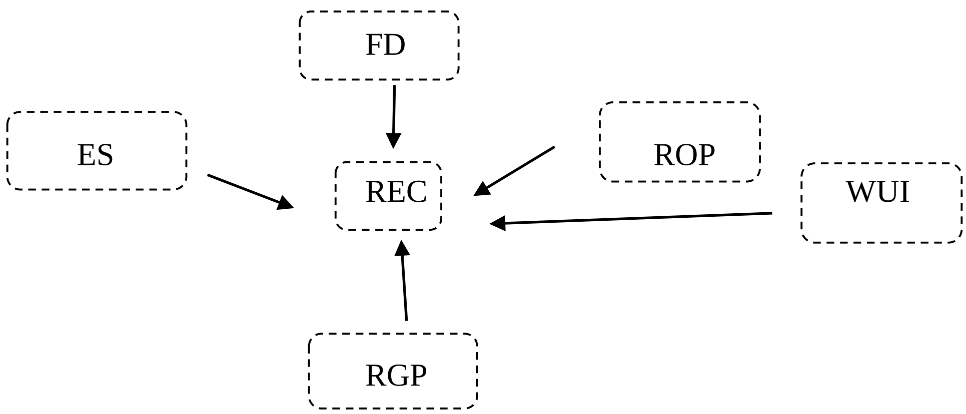
From the discovery of fire to the use of nuclear power, the production, consumption, and transfer of Energy have been the most crucial foundation of any society. The consumption of Energy, otherwise abbreviated as Energy consumption (EC), a vital necessity, is defined as the consumption or use of a given existing energy type for the production of goods and services, lighting, transportation, and other purposes (Uslu, 2020). The quantum leap in the use of energy began with the industrial revolution when humans first generated electricity and were then propelled forward with the discovery of coal which was used to power steam engines in the 18th century. With the discovery of crude oil which was obtained from biodegraded organic materials in the 19th century, a new source of Energy that surpassed all previous was utilized and is currently still one of the most important sources of Energy. Although Crude oil, coal, and gas are regarded as primary sources of energy, they are non-renewable and are therefore contingent upon the proven reserves discovered. These reserves are likely to last for at most a couple of decades, and therefore renewable energy is favored due to its inexhaustibility. This has caused an increase in the consumption of renewable energy; however, the installation costs of renewable energy projects far exceed that of oil and gas which in turn increases investors' anxiety towards such projects (Zhe, Li, et al. 2021). This is further driven by the current verity that renewable energy projects require long payback periods and therefore demand higher financing. To solve this problem, some countries have decreased the tax associated with renewable energy projects as compared to fossil fuels. In addition to that, governments lend subsidies to aid the growth of renewable energy projects.

However, according to Sadorsky (2010), a higher level of financial development leads to the developing of financial markets, bank, and equity markets, and therefore consecutively we would have more funds available for investment. Furthermore, financial development is correlated with the measure of capital flows in financial institutions, foreign direct investment (FDI), and capital markets and influences environmental quality through these three mechanisms (Zhang, 2011). Now by taking a look at energy as a whole, we realize there is a lack of consensus evidence in the correlation between energy consumption and economic growth which is primarily due to the omission of other potential determinants in the modeling of energy demand function (Chang, Shu-Chen 2015). However, according to the literature, there is a correlation between economic growth and investment in renewable energy. As a result, foreign investors take into account the economic conditions of the target country when making investment decisions. Countries with strong economic growth tend to attract more foreign investment. On the other hand, high inflation can lead to uncertainty in the market, which may discourage foreign investors from investing in renewable energy (R. Ma et al. 2021).

According to Sadorsky (2011), the level of financial development can impact energy consumption through three main channels: the direct effect, the wealth effect, and the business effect. The direct effect suggests that efficient financial intermediation can lead to an increase in the demand for renewable energy consumption by consumers. The business effect also impacts renewable energy consumption by providing firms with better access to financial capital, which can lower the cost of financing and increase the consumption of renewable energy (Baloch et al. 2021). The wealth effect is influenced by the assets that households and firms hold in a developed stock market (Anton & Nucu, 2020).

The determining factors of Energy consumption include gross domestic product, inflation, and so on; however, financial development is viewed as an effective factor that may have a strong contribution to Energy consumption (Gomez & Rodriguez, 2019:3). We will be breaking the determinants of renewable Energy consumption into the following; Financial development index (FD), Gross domestic product 2015 PPP, Uncertainty index, Real oil prices (ROP) and Retail Gasoline prices (RGP). As seen in the figure below, all these determinant factors affect the state of Renewable energy consumption in oil-importing and exporting countries.

Figure 1**.** REC and Determinants



Given that this paper is meant to show the effect of Uncertainty and financial development on renewable energy consumption in the case of oil importing and exporting countries in the MENA, then the inclusion determinants such as real oil prices and retail gasoline prices is justified. The economy size (ES) will be proxied by GDP 2015 PPP to further account for inflation. The Financial development index helps us determine if the development of the financial sector aids in pushing forward renewable energy use. According to the IMF, Financial development index (FD) is a relative ranking of nations based on access, depth, and efficiency of their financial markets and institutions and could be summarized in the table below:

Table 1: Financial development Index

Financial Institutions Index (FI)	
Depth	Bank credit to private sector/GDP Mutual fund assets/GDP Pension fund assets/GDP life and non-life/GDP
Access	Bank branches per 100.000 adults ATMs per 100.000 adults
Efficiency	Banking sector net interest margin Non-interest income/total income Lending-deposits spread Return on assets Overhead costs/total assets Return on equity
Financial Market Index (FM)	
Depth	Stock market capitalization/GDP Stocks traded/GDP International debt securities of government/GDP Total debt securities of financial and nonfinancial corporations/GDP
Access	Percent of market capitalization outside of top largest companies
Efficiency	Stock market turnover ratio

Source: IMF (2022)

The interest in the transition to renewables has been exacerbated by international negotiations. The Paris agreement in 2015 has emphasized the urgency to reduce global warming to well below 2 °C. That being, energy transition is a gradual process and usually takes time. According to International Renewable Energy Agency, even if an energy transition is technically feasible and economically beneficial, it will not automatically be realized. This forces policymakers to take immediate action if the financial conditions of the nation were stable. In recent years, renewable energy consumption in MENA countries has been on the rise, as these countries try to diversify their energy mixture while reducing their reliance on fossil fuels. According to the International Renewable Energy Agency, the MENA region has installed a capacity of 70 gigawatts (GW) of renewable energy in 2020, with the bulk of it emerging from solar and wind energy. Furthermore, several MENA countries such as Morocco and UAE aim to derive about 50% of their electricity from renewable sources by 2030 and 2050 respectively. The consumption of renewables in the MENA may also be affected by the impact of oil prices on exporting and importing countries which could vary drastically. It has been suggested that fluctuations in oil prices can lead to instability in various macroeconomic aggregates in both exporting and importing countries (Brinin et al., 2016). The dual importance of oil has led to the argument that its price is more volatile and unpredictable than that of any other commodity (Dehn, 2001). Exporting countries often rely heavily on oil revenue, so an increase in oil prices can provide more funding for development projects. However, fluctuations in oil prices can also create uncertainty in financial and real aggregates, particularly in cases where capital markets are imperfect. On the other hand, importing countries may face budget deficits if they are unable to immediately reduce their expenditures when oil prices fall. Oil production generally accounts for a large proportion of the GDP of oil exporting countries and the value of oil in currency terms increases the country's currency value although the total effect of oil price shocks on the performance of the economy largely depends on what the oil producers do with the additional revenue (Berument, 2010). Thus it is important to understand and predict the extent to which GDP in different countries is sensitive to these variations in oil prices, as they can have a significant impact on macroeconomic performance. The choice of the MENA region is especially important because it contains both radical oil imports and exports, therefore, making it a region of similar climate and opposing energy reserves. Furthermore, the region is intensifying its renewable energy projects, especially the GCC countries which were constantly dependent on oil. As stated earlier, countries like Morocco are constantly improving their transition to renewable energy despite institutional instability. This is feasible due to the solar energy potential of the region that absorbs a tremendous amount of direct normal radiation.

Since the global financial crisis, there has been a rise in global concerns regarding uncertainty. IMF reports indicate that uncertainty has been a major contributor to weaker economic performance in numerous economies. Despite this, advancements in measuring both economic and political uncertainty have only been made for a limited number of primarily developed economies. In order to address this issue, a new index called the World Uncertainty Index (WUI) was developed for 143 countries starting in the first quarter of 1990. This index is constructed using data from the Economist Intelligence Unit (EIU) country reports and measures uncertainty by counting the occurrences of the word "uncertainty" and its variations in these reports.

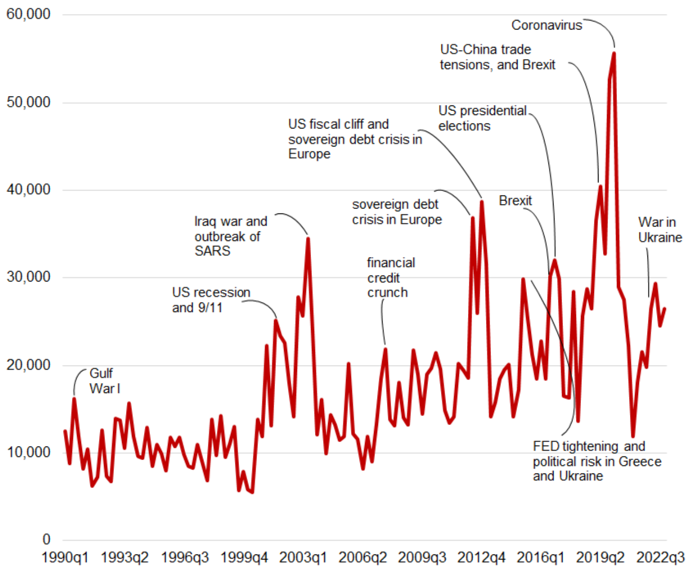


Figure 2: The World Uncertainty Index

Source: Ahir, Bloom and Furceri, "The World Uncertainty Index", mimeo.

The WUI has the advantage of reducing concerns about ideological bias and consistency. Additionally, it can be more easily compared across countries, making it particularly valuable for researchers studying the impact of cross-country variations in uncertainty on economic outcomes, such as foreign investment.

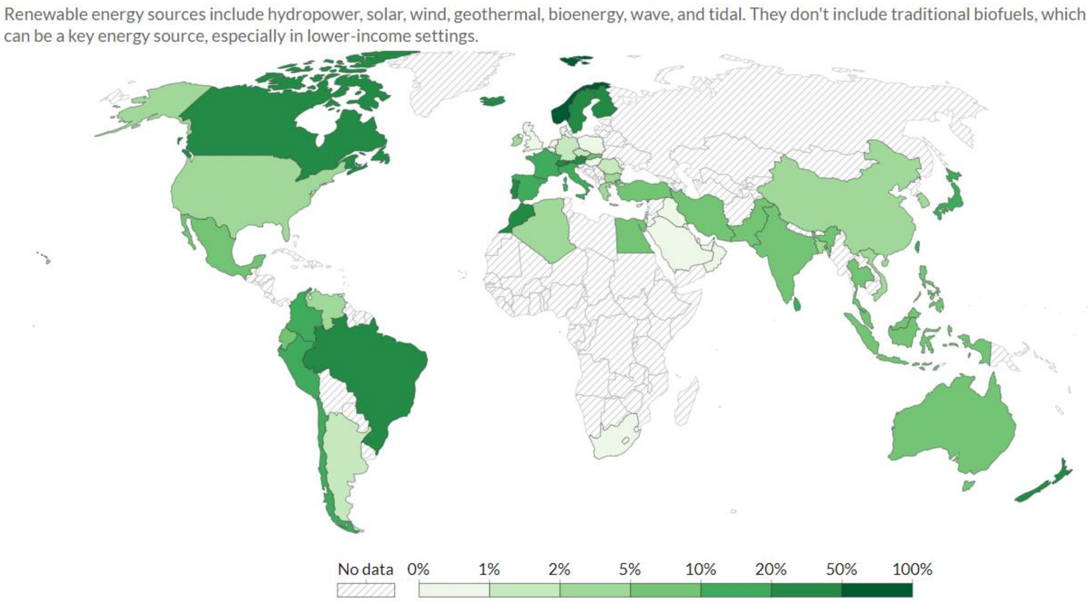
This paper is organized as follows, the second section contains a general account of sources of renewable energy in the MENA, the third section contains the literature review, the fourth section presents the model specification and data, the fifth section presents the results, discussions, the sixth chapter contains the robustness test, while the seventh section presents the conclusion and supporting policy recommendations.

CHAPTER II

RENEWABLE ENERGY IN THE MENA

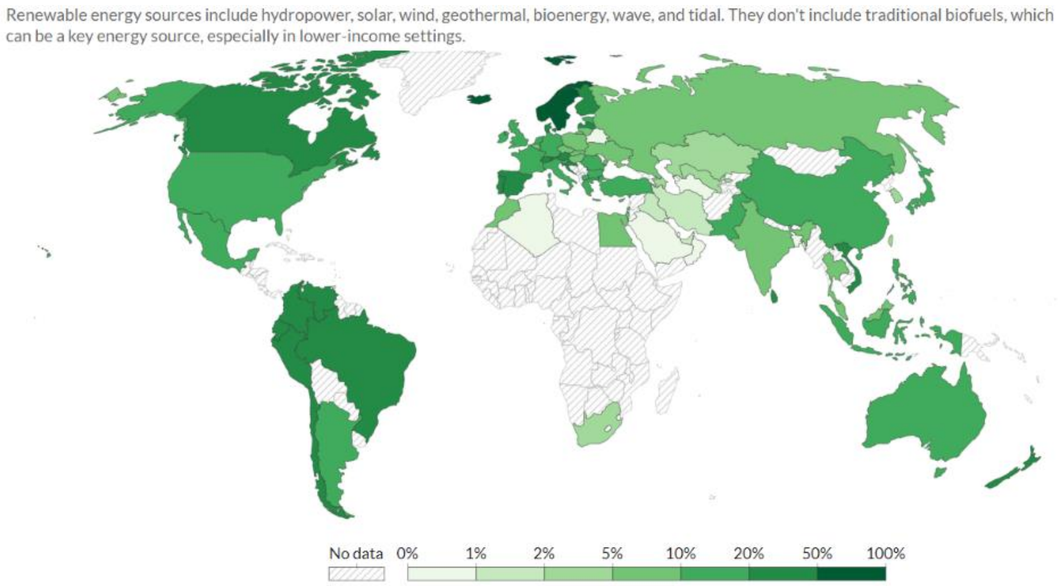
The MENA region is bestowed with a vibrant accumulation of natural resources that are sufficient for a strong renewable energy sector; Sunshine, strong winds, and in certain regions, strong river currents. The global demand for production factors has risen with the increase in GDP, leading to an increase in energy consumption worldwide. While the use of renewable energy sources has significantly increased globally in recent years, the MENA region has seen limited progress in this regard. As seen from figures 3 and 4, renewable energy consumption as a portion of total primary energy has only slightly increased in the MENA as compared to the rest of the world. Furthermore, the MENA has the lowest share of renewables as portion of total energy in the world.

Figure 3. Share of Primary Energy from renewable sources 1965



Source: Our World in Data based on BP Statistical Review of World Energy (2022)

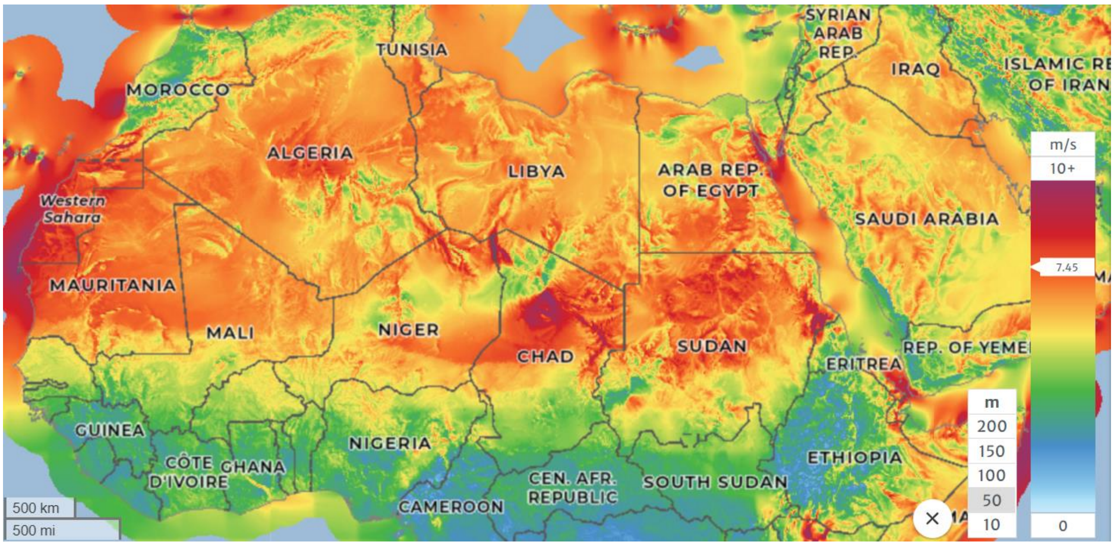
Figure 4. Share of Primary Energy from renewable sources 2021



Source: Our World in Data based on BP Statistical Review of World Energy (2022)

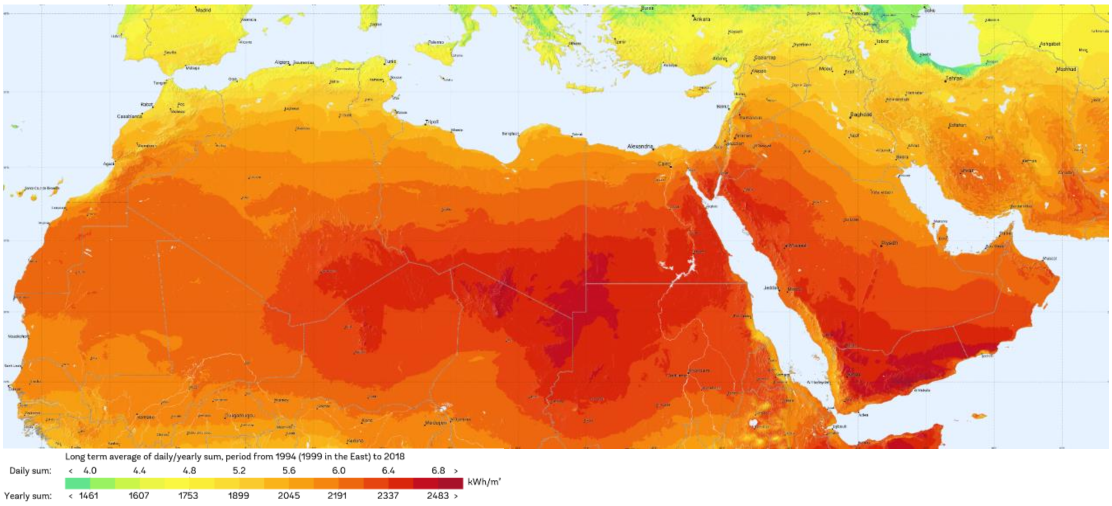
Despite the huge potential in terms of wind and solar, renewable energy, not including hydropower, is responsible for only about 1.5% of the electricity generation in the MENA, which is significantly lower than the world average which is more than 10%.

Figure 5: Wind speed in the MENA at speed of height of 50m



Source: Global Wind Atlas

Figure 6: Direct normal Irradiation



Source: World Bank, ESMAP, Solargis

As seen above, Figure 5 shows the wind speed at a height of 50m, and in most of the MENA region, shaded yellow, orange, and red, the average wind speeds exceed 5m/s which is the minimum sufficient speed required for the development of utilized wind farms. In Figure 6, we see that the Global horizontal irradiance, which is the total amount of short wave radiation received from above a surface that is horizontal to the ground, is highly abundant in the MENA region.

CHAPTER III

LITERATURE REVIEW

A. The effect of financial development on renewable energy consumption

The relationship between financial development and energy consumption has in recent years given rise to empirically mixed results. Some papers show that an increase in financial development results in a decrease in energy consumption while others show an increase in energy consumption. Sadorsky (2010) conducted a study on the relationship between financial development and energy consumption in 22 emerging countries, representing the first examination of this relationship in these economies. Using five measures of financial development, a linear dynamic model, as well as a generalized method of moment (GMM), he found that the impact of financial development on energy demand is positive and significant when the financial development is measured in the ratio of stock-market capitalization to GDP, stock-market value traded to GDP, and stock market turnover. Furthermore, he showed that the previous lagged energy consumption has a strong and positive impact on current energy demand.

Likewise, Shahbaz et al (2010) using an Autoregressive distributed lag (ARDL) bounds technique approach in Pakistan found that there exists a positive and significant correlation between financial development and energy consumption. This positive relation is also found by Xu (2012) who studied the effects in 29 provinces in China during the period of 1999-2009 using a GMM method. His results showed that there is a positive and statistically significant relationship between energy consumption and financial development given that financial development is measured in terms of the ratio of loans in a financial institution to GDP and the ratio of FDI to GDP. Similarly, S. Coban and M. Topcu (2013) used a sample of 27 EU countries and found that financial development had a positive and significant effect on energy consumption among the old EU members. In the case of the new member states, the effect is contingent upon the proxy used for financial development. For instance, using a bank index, the effect of financial development displays an inverted U-shaped pattern, however, no significant relationship was seen when a stock index was used. Using an error correction-based granger causality methodology, Ozturk and Acaravci (2013) showed that financial development had a positive and significant effect on energy consumption. In the case of Malaysia, Tang and Tan (2014) found that by applying a Johansen- Julius cointegration test and bounds approach, a long-run relationship exists between energy consumption and financial development. Even when taking into consideration a large number of countries such as the study conducted by Chang (2015) in which 53 countries over the period of 1999-2008 divided into high and non-high-income regimes were analyzed, similar results were confirmed. By using five different measures of financial development and income, the study found that in non-high-income countries, financial development had a positive and statistically significant effect on energy consumption when private and domestic credit were used as indicators of financial development. However, when stock market turnover and the value of traded stocks were used as indicators, the relationship between financial development and energy consumption declined slightly in advanced economies (high-income countries) but increased in higher-income countries in emerging markets. Rafindadi and Ozturk (2016) examined the relationship between financial development, economic growth, exports, imports, and electricity consumption in Japan from 1970 to 2012 using a structural break unit root test, ARDL bounds test approach to cointegration, and Johansen test. The study found that a 1% increase in financial development, economic growth, exports, and imports in Japan was associated with a corresponding increase in electricity consumption of 0.2429%, 0.504%, 0.0921%, and 0.2193%, respectively. Mahalik, Mantu Kumar, et al. (2017) conducted a study on the relationship between financial development and energy demand in Saudi Arabia using an autoregressive distributed lag (ARDL) approach that accounted for structural breaks in the data from 1971 to 2011. The results showed that there was a long-term relationship between financial development and energy demand in Saudi Arabia, with financial development contributing to energy demand. Furthermore, Kahouli (2017) also used an ARDL bounds approach and a VECM method to study the relationship between financial development and energy consumption in South Mediterranean countries. The study found a positive long-term causality between financial development and energy consumption in Israel, Morocco, and Tunisia. The granger causality analysis produced mixed results for individual countries. Liu et al. (2018) used the ARDL approach to study the relationship between financial development and energy demand in China and found that financial development had a positive influence on energy demand in both the short and long term.

However, as we have said earlier, many other papers have shown a negative relationship between financial development and energy consumption. For instance, Sadorsky (2010) showed that financial development might reduce energy consumption through the development of modern technologies. This negative effect is called the technological effect as mentioned by Tamazian et al. 2009, Jalil and Feridun 2011, Shahbaz et al. 2013 and so on. Altay and Topcu (2015) studying the case of Turkey by using cointegration and a causality methodology, show that there is no significant relationship between financial development and energy consumption for the period 1980-2011. This leads to an inconsistency across different papers in the case of Turkey which indicates that it does not matter what financial development indicator is used. Later, Topcu and Payne (2017) investigate the effect of financial development on energy consumption of 32 high-income countries over the years 1990-2014. Their results show that an increase in the stock market index yields a decrease in energy consumption. The main results show an absence of a relationship between the overall financial development index and energy consumption. Destek (2018) examined the relationship between energy price, real income, financial development, and energy consumption in 17 emerging economies using financial development that has been handled with three dimensions (banking sector, stock market, and bond market). Results show that banking and bond market development had a negative and statistically significant effect on energy consumption with the bond market being the most effective dimension in the reduction of energy consumption. With the application of a GMM and a vector autoregressive regression approach to analyzing China during the period of 1996Q1 to 2015Q4 concerning 30 Chinese provinces, Ouyang and Li (2018) found that financial development in the sense of M2, credit, and stock turnover could significantly reduce energy consumption. Canh et al. (2020) studied the multidimensional impact of financial development on consumption and production energy intensity of 81 countries from 1997 to 2013 and their results show that financial institutions have an increasing effect while financial markets have a decreasing impact on consumption energy intensity in the long run. Furthermore, in the presence of an oil price shock, countries with higher levels of financial development experienced a reduction in production energy intensity while countries with stronger financial institutions experience a reduction in consumption energy intensity.

There are a few papers that have analyzed the effect of financial development on renewable energy consumption. A pioneer in the study of this field is Brunnschweiler (2010) utilizing 119 non-OECD nations between the years 1980 and 2006 and indicated a significant connection between the variables. Wu and Broadstock (2015) studied data from 22 emerging market countries between the years 1990 and 2010 and they showed that financial development and institutional quality positively and significantly affect renewable energy consumption. Later Burakov and Friedin (2017) studied the case of Russia to find a relationship between financial development, economic growth, and renewable energy consumption from the period 1990 to 2014 by employing a VEC model. The results showed an absence of causality between financial development and renewable energy consumption. Kutan et al (2017) analyzed the effect of FDI flows and stock market development on renewable energy consumption taking into consideration four major emerging economies namely, Brazil, China, India, and South Africa over the period of 22 years from 1990-2012. Using a Fisher-Johansen panel cointegration technique, fully modified ordinary least squares, and panel non-causality test showed that FDI inflows and stock market development play a crucial role in encouraging renewable energy consumption. J Wang, S Zhang, and Q Zhang used an ARDL-PMG model to examine the long-term and short-term impacts of economic growth and financial development on renewable energy consumption in China at the national and regional levels, based on panel data from 1997 to 2017. Their results show that in the long run, economic growth in China as a whole and in western China has a positive effect on renewable energy consumption, while financial development has a negative effect. However, in the short run, economic growth has a negative impact on renewable energy consumption, while financial development has a positive impact. Anton and Nucu (2020) analyzed 28 EU countries over the period 1990-2015 using a panel fixed effect model. The results show that different financial development dimensions such as the bank sector, bond market, and capital market increase the share of renewable energy consumption.

Amine Lahiani and colleagues (2021) employed a non-linear autoregressive distributed lags (NARDL) model to examine the influence of financial development on renewable energy consumption in the United States from 1975Q1 to 2019Q4. The researchers considered three dimensions of financial development - stock-based, market-based, and overall financial development - and found that overall and stock market indices had a significant short-term effect on renewable energy consumption, while the banking index had no impact. In addition, in a paper published by Mukhtarov, Shahriyar, Serhat Yüksel, and Hasan Dinçer (2022), the authors utilized vector error correction model (VECM) and autoregressive distributed lags (ARDL) techniques to study the relationship between financial development and renewable energy consumption in Turkey. The results of the analysis showed that financial development had a positive and statistically significant impact on renewable energy consumption, with a 1% increase in financial development corresponding to a 0.21% increase in renewable energy consumption. In a study conducted by Nguyen (2022), the impact of financial development on renewable energy consumption was investigated in six Southeast Asian countries and three East Asian countries using the generalized least squares method. The results indicated that an increase in financial development had a negative impact on renewable energy consumption in these countries. Additionally, the analysis found that economic growth and lending rates had no effect on renewable energy consumption in the East and Southeast Asian countries under examination. In a study on the relationship between financial development and renewable energy consumption in Nigeria, Dimnwobi, Stephen Kelechi, et al (2022) employed a combination of the augmented Dickey-Fuller (ADF) test and Zivot-Andrew test to assess the stationarity properties of the data and account for potential structural breaks and used an autoregressive distributed lags (ARDL) model to examine the long-run relationship. The study used a broad-based financial development index that captured financial depth, access, and efficiency, and the results showed that the financial sector was critical for renewable energy consumption in Nigeria over the 1981-2019 period. In a study on the interactions between economic growth, foreign direct investment (FDI), financial development, and renewable energy consumption in the United Arab Emirates (UAE), Samour, Baskaya, and Tursoy (2022) used a bootstrapped autoregressive distributed lag model and Granger causality analysis to analyze data from 1989 to 2019. The authors found that financial development, FDI, and economic growth had a statistically significant positive impact on renewable energy consumption in the UAE. Recently, Le Thanh Ha (2022) conducted a study that examines the interaction between the Financial development index and environmental factors which include nonrenewable and renewable energy consumption in Vietnam at varying time frequencies from 1992 to 2019. The author demonstrates through the use of a multivariate wavelet model that there is a partial coherency between financial development and nonrenewable energy consumption during the period from 1998 to 2016, indicating that changes in financial development growth have led to growth in non-renewables and that the relationship is negative and vice versa from 2016 to 2019. Furthermore, a partial phase difference between financial development and renewable energy consumption between the time period 1994-2008 suggests the anti-phase relation with the rise of renewable energy consumption.

B. Effect of Uncertainty on renewable energy consumption

In recent decades, the role of uncertainty, especially economic political uncertainty, has been studied by researchers more often with regard to energy prices, consumption, and production. A significant amount of academic research has been conducted to study the relationship between economic policy uncertainty and energy prices. Among the many academics that have contributed to this field of study are Reboredo and Wen (2015) and Pastor and Veronesi (2012). According to Pastor and Veronesi (2013), a high EPU deepens the 'financial friction' in the capital market, increases equity financial costs, and escalates debt defaulting risks. While Yin and Han (2014) found that the relationship between these two variables changes over time, Ma et al. (2021) found evidence of a predictable relationship between economic policy uncertainty and energy prices.

Financial stress coupled with uncertainty is also important in determining renewable energy consumption. Cheng (2018) reported that uncertainty had a significant and negative impact on renewable energy consumption while Ji et al (2018) reported that energy market price varies in response to economic uncertainty. Furthermore, the impact of oil price shocks and economic policy uncertainty on renewable energy was also studied by Kang et al. (2017). According to the study, demand-side oil price shock has a beneficial effect on renewable energy companies whereas economic policy concerns have a negative influence on the consumption of renewable energy. Additionally, Chen and Kettunen (2017) investigated how economic policy uncertainty affected enterprises' carbon policies and found that the best course of action for businesses to take in order to reduce climate risk is to invest in renewable energy technology.

In a study, Lundgren et al. (2018) investigated the relationship between the use of renewable energy and the uncertainty brought on by changes in monetary and fiscal policy. The study emphasized the significance of uncertainty in regard to the volatility and results of consuming renewable energy. Later on, Zhang et al. (2019) reported that policy uncertainty is more important in the framework of renewable energy consumption than that non-renewable energy consumption. The latest economic policy uncertainty witnessed was the COVID-19 pandemic that increased the uncertainties related to bank and stability, energy stock returns, investment, financial growth and development, firm's cash flow, and renewable energy consumption (Iyke, 2020; Appiah-Otoo 2020). Sohail et al. (2021) studied the effects of monetary policy uncertainty on renewable and non-renewable energy consumption in the US and found that monetary economic policy had short and long-run negative effects on renewable energy consumption in the linear model, while a decreasing monetary uncertainty has a significant negative effect on renewable energy consumption in the non-linear model. Recently, Lei et al. (2021) studied the effect of financial development and economic policy uncertainty in China and found that a positive change in EPU increased renewable energy consumption while a negative change has to decrease renewable consumption in the long run.

Previous papers have usually addressed isolated countries or classified countries as either emerging economies or non-emerging economies or high-income and non-high-income countries while using one or two variables to measure financial development. This paper is the first, to my knowledge, to investigate the effect of uncertainty and financial development on renewable energy consumption in the dimensions of Oil importing and exporting countries of the MENA region while simultaneously using a broad-based financial development index and account of subsidies.

CHAPTER IV

DATA AND EMPIRICAL MODEL

A. Data

In this study, we use yearly data for renewable energy consumption, World uncertainty index, broad financial development, GDP 2015 PPP, real oil prices, and pump gasoline prices over the period 1990-2020. The financial development index structured as a relative ranking of countries on the depth, access, and efficiency of financial institutions and financial markets are derived yearly from the period of 1990 to 2020 from the IMF Financial development index data base, whereas the data of the crude oil price is represented by the Brent crude oil spot prices, which are collected from the International Energy Agency. Retail gasoline prices are collected from the GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit) database, IMF, IEA, and numerous newspapers. Authors in the literature on the topic have usually used CPI as a proxy for energy prices due to the difficulty of attaining energy prices (see Chang (2015), Sadorsky (2010), Yazdi & Shakouri (2017), Gabriel & Nucu (2019), etc.), however, CPI measures the average change in prices of a basket of goods and services consumed by households and thus does not specifically track energy prices, which can fluctuate independently of other prices. For an Overview of Existing Databases on Retail Fuel Prices, see Appendix I. We will use the ratio of pump gasoline to Brent crude oil price to produce an index that approximates the subsidies a country places on gasoline. The study uses data from 18 MENA countries: 9 oil exporting countries which include Saudi Arabia, Qatar, UAE, Bahrain, Yemen, Kuwait, Iran, and Algeria as well as 9 oil importing countries which include Egypt, Turkey, Morocco, Tunisia, Jordan, Israel, Mauritania, Sudan, and

Lebanon. The selection of countries is limited due to the unavailability of data as well as the homogeneity of countries.

Table 2 Summary of variable definition, and source of data

Names	**Abbreviations**	**Definitions**	**Sources**
Renewable energy consumption	REC	Renewable energy consumption is total clean energy consumed in quad Btu.	U.S. Energy Information Administration (EIA)
Financial development index	FD	Broad-based index of financial access, depth, and efficiency	World Bank database based on Svirydzenka (2016) index
Gross domestic product 2015 PPP	ES	It measures the economic output of a nation	U.S. Energy Information Administration (EIA)
Real oil prices (Brent)	ROP	Spot price of a barrel of crude oil represented by the Europe Brent spot price FOB	U.S. Energy Information Administration (EIA)
Pump Gasoline price	PGP	The pump Gasoline price gives the price of gasoline sold at a particular period of time in a particular country. It represents a form of Energy price in the country.	GIZ, IMF, IEA, and newspaper publications.
World Uncertainty Index	WUI	The index reflects the frequencies of the word “uncertainty” (and its variants) in the EIU country reports	Ahir, Bloom and Furceri, "The World Uncertainty Index", mimeo.
Pump Gasoline to Brent oil prices	PGPI	The index measures the subsidies a country places on oil at a particular period of time	See PGP and ROP

Table 3 shows the descriptive statistics for the panel data with 18 countries and 558 country time observations. The standard deviation of REC in the Oil importing countries is 0.367, which is about ten times the standard deviation of REC in exporting countries thus indicating more diversity in the sample.

Table 3 panel data descriptive statistics

Panel Importing Countries

Variable	**Mean**	**Max**	**Min**	**Std.dev.**	**Skew.**	**Kurtosis**
REC	0.0806	1.1842	-0.0122	0.3670	3.4464	16.527
FD	0.2868	0.6432	0.0327	0.1592	0.3086	2.0333
ES	325.26	2380.87	1.00E-06	475.40	2.3022	8.1546
PGPI	253.09	803.66	21.729	146.09	0.9450	3.6608
WUI	0.1526	0.7482	0.0000	0.1502	1.6388	6.2143

Panel Exporting Countries

Variable	**Mean**	**Max**	**Min**	**Std.dev.**	**Skew.**	**Kurtosis**
REC	0.0133	0.1978	-0.0021	0.0365	3.0647	11.764
FD	0.3000	0.5719	0.0889	0.1519	0.0224	1.5378
ES	397.65	1772.46	18.141	413.37	1.4882	4.5988
PGPI	82.027	335.33	6.5241	58.769	1.0978	4.3112
WUI	0.1154	0.9383	0.0000	0.1128	2.4267	13.623

Source: Author's estimation

The highest renewable energy consumption in quad Btu found in the oil importing countries is Turkey which was about 1.1842 in 2019 while the highest in oil exporting countries is Iran with about 0.1978 in 2006. In the sample, the minimum level of renewable energy consumption is registered in Kuwait over the period 1990-2001, Libya over the period 1990-2004, Saudi Arabia over the period 1990-2009, UAE over the period 1990-1999, Bahrain over the period 1990-2005, Qatar over the period 1990-2010, and Yemen over the period 1990-2009 all of which registered 0 Btu and belong to the oil-exporting countries. With regards to the level of financial development, oil-importing countries registered an average of 0.2868 with a maximum of 0.6432 in Israel in 2008 and a minimum of 0.0327 in Sudan in 2001, while oil-exporting countries registered an average of 0.3000 and a maximum of 0.5719 in UAE in 2014 and a minimum of 0.0889 in Yemen in 2003. It is intuitive that oil-exporting countries would possess a higher level of financial development due to the inflow of foreign hard currency into the country. With regards to the uncertainty index, the average in oil importing countries was 0.1526 with a maximum of 0.7482 in Tunisia in 2011 and an average of 0.1154 with a maximum of 0.9383 in Algeria in 2019 in oil exporting countries.

Table 5 below shows the correlation matrix of dependent and independent variables.

Table 4**:** Correlation Matrix

Oil Importing Countries

Correlation	**REC**	**FD**	**ES**	**PGPI**	**WUI**
REC	1.0000				
FD	0.2822***	1.0000			
	[4.8948]				
ES	0.9176***	0.3551***	1.0000		
	[38.459]	[6.3223]			
PGPI	0.1199**	0.0634	0.0198	1.0000	
	[2.0105]	[1.0577]	[0.3298]		
WUI	0.30968***	0.2173***	0.2955***	-0.1035*	1.0000
	[5.4206]	[3.7050]	[5.1477]	[-1.7318]	

t-statistic in [] where ***, **, * denote significance at 0.01, 0.05, and 0.1 respectively.

Oil exporting countries

Correlation	**REC**	**FD**	**ES**	**PGPI**	**WUI**
REC	1.0000				
FD	0.02956	1.0000			
	[0.4921]				
ES	0.4465***	0.1703***	1.0000		
	[8.3065]	[2.8757]			
PGPI	-0.2102***	- 0.1827***	-0.2612***	1.0000	
	[-3.5786]	[-3.0924]	[-4.5032]		
WUI	0.0894	-0.0061	0.1115*	-0.1385**	1.0000
	[1.4942]	[-0.1015]	[1.8678]	[-2.32737]	

t-statistic in [] where ***, **, * denote significance at 0.01, 0.05, and 0.1 respectively.

B. Empirical Model

Following on the work of Shin et al. (2014), we construct a non-linear ARDL model which is a dynamic heterogeneous panel data model that has been adapted to a panel form, making it suitable for use with large panels with a large number of time periods (T). This nonlinear representation allows for more accurate modeling of complex relationships within the data. The NARDL model is a multivariate econometric model that is used to accommodate possible cointegration relationships between time series having different orders of integration. Conventional cointegration tests such as the Johansen (1998), Engle and Granger (1987) both require time series to be of the same order of integration whereas the NARDL is more effective in that it can allow for the mix of I (0) and I (1) without generating spurious results. Furthermore, the model is relevant in frameworks where the time series are not cointegrated, but their respective negative and positive components have a long run connection, or otherwise known as hidden cointegration, which is useful in the detection of energy and economic policies. NARDL is also flexible enough to avoid under-fitted or over-fitted modeling of adjustments of system variables in the long-run and short run since it allows for non-linearity between underlying variables in both short and long run.

However, we first begin by assuming a symmetric response of renewable energy consumption to uncertainty shocks after which we could relax the assumption of symmetry and allow for positive and negative changes in uncertainty. We begin with a symmetric panel ARDL model which has the following form:

$$y = \sum_{j=1}^{p} \phi_j y_{t-j} + \sum_{j=0}^{q} \theta_j x_{t-j} + \varepsilon_{\mathrm{t}}$$

Taking into consideration the case of renewable energy consumption and the determinants we included,

$$\Delta REC_t = \alpha_0 + \alpha_{REC} REC_{t-1} + \alpha_{FD} FD_{t-1} + \alpha_{ES} ES_{t-1} + \alpha_{WUI} WUI_{t-1} + \alpha_{PGPI} PGRI_{t-1} + \sum_{i=1}^{\mathrm{p}-1} \delta_i \Delta\, REC_{t-i} + \sum_{i=1}^{\mathrm{q}-1} \gamma_i \Delta\, FD_{t-i} + \sum_{i=1}^{\mathrm{q}-1} \omega_i \Delta\, ES_{t-i} + \sum_{i=1}^{\mathrm{q}-1} \varphi_i \Delta\, WUI_{t-i} + \sum_{i=1}^{\mathrm{q}-1} \pi_i \Delta\, PGPI_{t-i} + \varepsilon_t$$

Where $REC_t, FD_t, ES_t, WUI_t \; and \; PGPI_t$ denotes renewable energy consumption, financial development, Economy size, world uncertainty index, and pump gasoline price index respectively. P and q refer to the lag orders of dependent and explanatory variables and Δ refers to first difference transformation. In this model, the Financial development used is the broad based financial development measure developed by Svirydzenka (2016) which compresses the various elements of financial development into an index that comprises both financial markets and financial institutions into distinct themes namely; access: companies and individual's capacities to obtain financial services; depth: markets size and liquidity; and efficiency: the ability of institutions to offer financial services at a lower rate and with sustainable revenues. For each cross section, the long run slope coefficient is computed as $-\frac{\alpha_{FD}}{\alpha_{REC}}$ since in the long run, it is assumed that $\Delta REC_{t-i} = 0$ and $\Delta\, FD_{t-i} = 0$. Thus the short run estimate for FD is obtained as γ_i.

Although the ARDL model has several advantages over other cointegration techniques, it has the risk of forcing a nonlinear relationship between uncertainty and renewable energy consumption, and therefore we will propose a modified version, namely the NARDL model:

$$y = \sum_{j=1}^{p} \phi_j y_{t-j} + \sum_{j=0}^{q} \left(\theta_j^{+'} x_{t-j}^{+} + \theta_j^{-'} x_{t-j}^{-}\right) + \varepsilon_t$$

$$x_t^{+} = \sum_{j=1}^{t} \Delta x_j^{+} = \sum_{j=1}^{t} \max(\Delta x_j, 0)\ and\ \ x_t^{-} = \sum_{j=1}^{t} \Delta x_j^{-} = \sum_{j=1}^{t} \min(\Delta x_j, 0)$$

Where x_t is decomposed as $x_t = x_0 + x_t^{+} + x_t^{-}$ and x_t^{+} and x_t^{-} represent the partial sum processes of positive and negative changes in x_t. In our case, we would transform WUI that would translate to:

$$\begin{aligned} \Delta REC_t = {} & \alpha_0 + \alpha_{REC} REC_{t-1} + \alpha_{WUI}^{+} WUI_{t-1}^{+} + \alpha_{WUI}^{-} WUI_{t-1}^{-} + \alpha_{FD} FD_{t-1} + \alpha_{ES} ES_{t-1} \\ & + \alpha_{PGPI} PGPI_{t-1} + \sum_{i=1}^{\mathrm{p}-1} \delta_{\mathrm{i}} \Delta\, REC_{t-i} + \sum_{i=1}^{\mathrm{q}-1} \gamma_{FD}\, \Delta FD_{t-i} \\ & + \sum_{i=1}^{\mathrm{q}-1} (\omega_{ES} \Delta ES_{t-i}) + \sum_{i=1}^{\mathrm{q}-1} (\varphi_{WUI}^{+} \Delta WUI_{t-i}^{+} + \varphi_{WUI}^{-} \Delta WUI_{t-i}^{-}) \\ & + \sum_{i=1}^{\mathrm{q}-1} (\pi_{PGPI} \Delta PGPI_{t-i}) + \varepsilon_{\mathrm{t}} \end{aligned}$$

In this model, positive and negative shocks are not expected to have the same impact on renewable energy consumption. The long run coefficients for $WUI^{+}$and WUI^{-} are calculated as $\beta_{WUI}^{+} = -\frac{\alpha_{WUI}^{+}}{\alpha_{REC}}$ and $\beta_{WUI}^{-} = -\frac{\alpha_{WUI}^{-}}{\alpha_{REC}}$. Thus the short run asymmetric impact of financial development on renewable energy consumption is conducted using a Wald test of the null $\gamma_i^{+} = \gamma_i^{-}, i = 1,2, \ldots, q-1$ and the long run by $\beta_{WUI}^{+} = \beta_{WUI}^{-}$.

CHAPTER V

EMPIRICAL RESULTS AND DISCUSSIONS

The first step is to test for cross sectional dependence which is a step numerous papers have omitted although it is a very crucial step that might reveal spurious results if ignored. We therefore test for cross country dependence using Lagrange multiplier test developed by Breusch–Pagan (1980), the scaled version of the Lagrange multiplier suggested by Pesaran (2004), and the cross-sectional dependence (CD) test suggested by Pesaran (2004).

Table 5 presents the results for cross sectional dependence in which the null hypothesis of the Breusch-Pagan and Pesaran tests is the absence of cross sectional dependence. As seen in the table below, although Pesaran CD rejects the presence of cross dependence, Breusch-Pagan LM and Pesaran Scaled LM suggest the presence of it and therefore we can conclude that cross sectional dependence exists in the data.

Table 5**:** Cross sectional dependence test

Oil importing

Test	Statistic	d.f.	Prob.
Breusch-Pagan LM	192.991	36	0.0000
Pesaran Scaled LM	18.5015		0.0000
Pesaran CD	0.9945		0.3200

Oil exporting

Test	Statistic	d.f.	Prob.
Breusch-Pagan LM	265.63	36	0.0000
Pesaran Scaled LM	27.065		0.0000
Pesaran CD	9.7571		0.0000

The second step is to analyze the order of integration of the variables. We use the first-generation tests: the unit root tests of Levin et al. (2002) and Im et al. (2003). The null hypothesis of these two tests is that the series have a unit root. Then we use second generation tests given the presence of cross sectional dependence.

Table 6: First generation: Levin, Lin & Chu and Im, Pesaran and Shin W-stat unit root tests. Second generation: Critical values for the Phillips-Perron, cross augmented dickey fuller unit root test

Panel importing countries

	First generation tests				Second generation tests			
Tested Variable	**LLC** t-^{STAT} **I(0)**	**LLC** t-^{STAT} **I(1)**	**IPS** t-^{STAT} **I(0)**	**IPS** t-^{STAT} **I(1)**	**CIPS** t-^{STAT} **I(0)**	**CIPS** t-^{STAT} **I(1)**	**CADF** t-^{STAT} **I(0)**	**CADF** t-^{STAT} **I(1)**
REC	6.195	-3.843**	5.927	-5.545**	-0.7600	-4.275**	-0.695	-3.137**
FD	-1.424	-10.17**	0.677	-9.948**	-2.0830	-5.435**	-2.049	-4.376**
WUI	-3.174**	======	-3.010**	======	-3.304**	=======	-2.670**	======
ES	1.914	-7.028**	4.377	-5.592**	-0.768	-3.689**	-1.452	-3.008**
PGPI	-2.298*	-13.39**	-2.101*	-12.66**	-1.520	-4.267**	-2.026	-3.847**

[* denotes significance at the 5% and ** denotes significance at the 1%]

Panel exporting countries

	First generation tests				Second generation tests			
Tested Variable	**LLC** t-^{STAT} **I(0)**	**LLC** t-^{STAT} **I(1)**	**IPS** t-^{STAT} **I(0)**	**IPS** t-^{STAT} **I(1)**	**CIPS** t-^{STAT} **I(0)**	**CIPS** t-^{STAT} **I(1)**	**CADF** t-^{STAT} **I(0)**	**CADF** t-^{STAT} **I(1)**
REC	7.146	-2.280*	7.348	-2.925**	0.626	-3.338**	0.1340	-1.879*
FD	-0.735	-8.181**	-0.052	-8.135**	-2.37*	-5.383**	-2.599**	=======
WUI	-4.237**	======	-4.274**	=======	-3.760**	=======	-3.319**	=======
ES	-1.890*	======	1.266	-3.600**	-2.315	-3.946**	-2.508**	=======
PGPI	-0.267	-10.41**	-0.641	-10.83**	-2.181	-4.928**	-1.993	-3.360**

[* denotes significance at the 5% and ** denotes significance at the 1%]
Source: Author's estimate

In the Oil importing countries, first generation tests reveal that WUI is stationary at level while all other variables are stationary at their first difference. In the Oil exporting countries, WUI is also stationary at level while the other variables are stationary at their first difference. This implies that the selected variables have either an I (0) or an I (1) order of integration and therefore the NARDL condition of stationary holds. However, these unit root results are unreliable due to the presence of cross sectional dependence, therefore we adopt second generation Critical values for the Phillips-Perron (CIPS) Unit root test and the cross augmented dickey fuller (CADF) unit root test developed by Pesaran (2007) as seen in Table 6. For Oil importing countries, in both the cases of CIPS, and CADF, WUI is stationary at I (0) while all the other variables are stationary at I (1). The same hold for CIPS in oil exporting countries, however, FD, WUI, and ES are stationary at level when conducting a CADF test. Since all variables are at most stationary in I (1), then we can apply the NARDL approach.

We will then test for cointegration using the Kao panel cointegration test, after which we will apply the Westerlund (2007) panel cointegration which offers a distinct advantage due to its capability in handling cross-sectional data that exhibit dependencies. The test is composed of four different statistical assessments, which are based on the Error Correction Model (ECM), and they aim to address the limitations of other tests. The results of the cointegration tests are given in table 7 in which Gt and Ga examine the hypothesis that at least one-unit root is cointegrated whereas Pt and Pa focus on the cointegration of the panel. The group mean tests (denoted by Gt and Ga) examine the null that at least one unit is cointegrated, while the panel tests (Pt and Pa) examine the alternative that the panel is cointegrated.

Table 7: Kao and Westerlund Cointegration tests

Kao cointegration test

Null: No cointegration
Alternative: All panel are cointegrated

Oil importing		Statistic	P-value
	Modified Dickey-Fuller t	2.1978	0.0140
	Dickey-Fuller t	3.2989	0.0005
	Augmented dickey-Fuller t	4.4319	0.0000
Oil exporting		Statistic	P-value
	Modified Dickey-Fuller t	-3.3445	0.0004
	Dickey-Fuller t	-2.7266	0.0032
	Augmented dickey-Fuller t	-3.9789	0.0000

Westerlund Cointegration test

Oil importing	Statistic	Value	Z value	P-value
	Gt	-1.006	2.837	0.998
	Ga	-3.365	2.748	0.997
	Pt	-7.888	-2.398	0.008***
	Pa	-9.050	-1.205	0.114
Oil exporting	Statistic	Value	Z value	P-value
	Gt	-0.537	4.207	1.000
	Ga	-2.514	3.107	0.999
	Pt	-7.661	-2.218	0.013**
	Pa	-10.496	-1.798	0.036**

, and * denote the significance at 5, 1%

After running our cointegration tests, our results show that cointegration is present in at least one unit.

A. ARDL and NARDL results

We used a pooled mean group autoregressive distributed lag (ARDL) and non-linear ARDL to estimate the effects of uncertainty and financial development on renewable energy consumption for both the cases of oil importing and exporting countries. The results are shown in Table 8 below.

Table 8: ARDL and NARDL results for Oil Importing countries

Model Selection method: Bayesian Schwartz criteria

	ARDL Coefficient	Std. error	t-Statistic	NARDL Coefficient	Std. error	t-statistic
Panel A: long run estimates						
FD	-0.172***	0.0663	-2.6052	-0.1719**	0.0871	-1.9743
WUI	0.0281	0.0236	1.2141			
WUI^{+}				-0.0658**	0.0339	-1.9350
WUI^{-}				-0.0448	0.0363	-1.2341
ES	0.0006***	7.28E-05	7.5489	0.0006***	0.0001	6.1599
$PGPI$	2.98E-05*	1.71E-05	1.7438	3.08E-05*	1.78E-05	1.7296
Panel B: short run estimates						
$CointegrationEq.$	-0.1185**	0.0616	-1.9245	-0.0918*	0.0513	-1.7874
$D(FD)$	0.0244**	0.0123	1.9745	0.0171*	0.0100	1.7049
$D(WUI)$	0.0092*	0.0055	1.6693			
$D(WUI^{+})$				0.0162*	0.0102	1.5760
$D(WUI^{-})$				0.0059	0.0149	0.4107
$D(ES)$	2.39E-05	6.52E-05	0.3665	6.40E-05	5.4E-05	1.1973
$D(PGPI)$	3.30E-05	0.0050	1.0909	3.53E-05	3.4E-05	1.0347
$Constant$	-0.0073*	0.0050	-1.4656	-0.0074*	0.0054	-1.3755

*, **, *** denote significance at the 10%, 5%, and 1% level.
Testing WUI for Asymmetry, $\mathbf{Chi^2\ (1) = 1.68\ \ Prob > \ Chi^2 = 0.1949}$

Table 9: ARDL and NARDL results for Oil Exporting countries

Model Selection method: Bayesian Schwartz criteria

	ARDL Coefficient	Std. error	t-Statistic	NARDL Coefficient	Std. error	t-statistic
Panel long run estimates						
FD	-9.56E-05	0.0007	-0.1397	0.0017	0.0165	0.1007
WUI	0.0012**	0.0005	2.3233			
WUI^{+}				-0.034***	0.0127	-2.726
WUI^{-}				-0.071***	0.0197	-3.632
ES	7.E-06***	9.E-07	7.8415	6.29E-06	1.44E-05	0.4378
$PGPI$	1.43E-06	1.E-06	1.4352	1.19E-05	1.6E-05	0.7267
Panel short run estimates						
$CointegrationEq.$	-0.1012	0.1497	-0.6762	-0.1145**	0.0584	-1.962
$D(FD)$	-0.0126	0.0134	-0.9445	-0.0285	0.0273	-1.045
$D(WUI)$	-0.0033	0.0025	-1.3321			

$D(WUI^{+})$				0.0062	0.0051	1.2043
$D(WUI^{-})$				-0.0060	0.0075	-0.804
$D(ES)$	1.91E-05	2.81E-05	0.6802	1.79E-05	3.16E-05	0.5663
$D(PGPI)$	2.76E-06	4.03E-06	0.6846	6.08E-06	6.01E-06	1.0122
$Constant$	0.00314	0.0029	1.0650	0.0011	0.0023	0.4641

*, **, *** denote significance at the 10%, 5%, and 1% level.

Testing WUI for Asymmetry, $\mathbf{Chi^2\ (1) = 1.58}$ $\mathbf{Prob > \ Chi^2 = 0.2087}$

1. Long run results

The long-run NARDL-PMG estimate of the uncertainty in the oil-importing countries indicates that positive shocks in uncertainty exert a significant and negative effect on renewable energy consumption, while a negative effect exerts no significant effect. The coefficient estimates of a positive shock in uncertainty infer that a percentage increase in uncertainty leads to a 0.0658% reduction in renewable energy consumption. In oil-exporting countries, the results show that a positive and a negative shock in uncertainty exert a negative and significant effect on renewable energy consumption. The coefficient estimate of a positive and negative shock in uncertainty infers that a percentage increase in uncertainty leads to a 0.0347% and 0.0714% decrease in renewable energy consumption. These findings are in line with policy uncertainty such as that of Sohail et al. (2021) and Zeng et al. (2021), who noted that monetary policy uncertainty has negative effects on renewable energy consumption in the Short and long run, and economic policy uncertainty has negative effects on renewable energy investment and consumption. Given that both positive and negative shocks in uncertainty impact financial development (as seen in the Dumitrescu–Hurlin panel causality tests below), investment, household savings, tourism, bank stability, and so on (AL-Thaqeb and Algharabali 2019), it negatively affects renewable energy consumption. Uncertainty blocks the use of renewable energy sources due to the use of other sources that are more easily affordable. Policymakers become more cautious and less likely to implement supportive policies in an uncertain situation in any economy (Zeng et al. 2021). According to Sohail et al. (2021), policy uncertainty has a negative impact on both investments in renewable energy and the consumption of renewable energy, referred to as the "consumption effect." Furthermore, as reported by Pirgaip and Dincergok (2020), economic policy uncertainty has a dynamic effect on energy consumption, thus inactivating a demand shock for energy consumption which then negatively affects renewable energy consumption (Zeng et al 2021). A negative shock in uncertainty in oil-importing countries is not as significant because the use of renewable energy is often motivated by the need to diversify the energy mix and reduce the dependency on fossil fuels. Therefore, the goal of reducing oil dependence takes precedence over other factors such as uncertainty level and thus renewable energy consumption may not be affected. Furthermore, in oil-importing countries, governments provide significant subsidies for renewable energy projects which might mitigate the effects of a negative shock of uncertainty on renewable energy consumption. In oil exporting countries, on the other hand, a negative uncertainty shock may significantly affect renewable energy consumption given their higher oil exporting dependency.

The findings also suggest that in oil-importing countries, Financial development has a significant and negative effect on renewable energy consumption, a one percent increase causes a 0.1719% decrease in renewable energy consumption. These results are in line with Nguyen (2022) who found that financial development had a negative effect on renewable consumption in Southeastern Asian countries (who happen to be oil importers). This could be explained because as economies continue to grow, the demand for energy increases therefore the reliance on fossil increases. In addition to that, as the cost of renewable energy technologies decreases and their deployment increases, the fossil fuel price may become even more attractive relative to that of renewable sources. According to Nguyen (2022), many Southeast Asian economies have prioritized increasing their economic performance through significant growth in financial development. For instance, countries like Vietnam and the Philippines have lower average incomes but higher levels of financial development compared to Indonesia.

Furthermore, the findings are in line with Wang et al. (2018) in which the case of China was studied and in the long run, a negative relationship between financial development and renewable energy consumption is seen. The negative nexus between financial development and REC can be explained by the underdeveloped financial sector. For instance, low-quality financial institutions and higher financial costs prevent investments in renewable energy infrastructures and technologies. Furthermore, financial development can lead to more investment competition, creating a more difficult funding environment for renewable energy projects. Consequently, securing capital for renewable energy projects can become challenging, resulting in limited access to funding and difficulty in implementing such projects.

In oil-exporting countries, Financial development does not have any significant effect on renewable energy consumption. This result tells us that in the long run, financial development will not improve the substitution between non-renewable and renewable energy in oil-exporting countries in the MENA. This could be argued for because oil-importing countries have already a vested interest in maintaining their oil-based economic dominance. Therefore, investing in renewables may be viewed as a risk to their primary source of income. This tells that the region must, therefore, make efforts to regulate the financial system to have an impact on renewable energy and green investments.

In terms of economic growth, the result shows that income has a positive effect on renewable energy consumption. Therefore, it is expected that for every one percent increase in income, there is a 0.0006% increase in renewable energy consumption at the 1% significance. The result is in line with Saadaoui (2022), Tiba and Belaid (2021), Islam et al. (2022), Samour et al. (2022), Sadorsky (2009), Silva et al. (2018), Alam and Murad (2020), and Chen (2018), where the research object is emerging countries, SubSaharan Africa, OECD countries, and China.

They are however, in contrast to Cardoret and Padovano (2016), Uzar (2021), lie et al. (2021), and Shahbaz et al. (2021). In oil-exporting countries, economic size has no significant effect on renewable energy consumption.

Finally, in terms of pump gasoline to the crude oil price, there is a positive and significant effect such that for every 1% increase in pump gasoline to the crude oil price, there is a 3.08E-05 % increase in renewable energy consumption in oil-importing countries. There is no significant effect in oil-exporting countries.

2. Short run results

The short-term interactions between the variables in the model can give insight into how adjustments are made to reach a long-term equilibrium. Our results show that the error correction term (ECT), which measures the speed of adjustment towards equilibrium, is significant and negative therefore suggesting convergence. This suggests the presence of a long-term relationship between the variables and a rapid correction towards balance. Since cointegration equation is negative and significant, the variables are cointegrated and the variables jointly granger cause renewable energy consumption in the long run. The rate at which the model adjusts to the long run equilibrium is 0.0918 for the oil importing countries, and 0.1145 for the oil exporting countries. Therefore, the model corrects its state of disequilibrium at an adjustment rate of 0.0918 and 0.1145 per year when an external shock is applied to the model for Oil-importing and exporting countries. Table 9 also provides the short run results, and as presented, a positive shock to uncertainty has a positive and significant effect on renewable energy consumption in oil importing countries. The reason for this is that when uncertainty rises, individuals and businesses may become warier of risk and look to broaden their energy sources in order to mitigate the impact of uncertain future oil prices. This heightened demand for renewable energy can cause a temporary increase in its consumption. The results show that a 1% increase in uncertainty leads to a 0.0162% increase in renewable energy consumption. In oil exporting countries, both the negative and positive shocks in uncertainty have no significant effect on renewable energy consumption.

Financial development showed a positive and significant effect on renewable energy consumption in oil importing countries. The coefficient estimates of financial development infer that a percentage increase in financial development leads to a 0.0171% increase in renewable energy consumption. This is in line with Wang et al. (2018) in which a financial development caused a positive effect on renewable energy consumption in the short run. This is because the growth of the financial sector, including the availability of loans and financial instruments, can provide individuals and businesses with easier access to financing, enabling them to make investments in renewable energy projects. This rise in investment can result in a temporary rise in the supply of renewable energy, thereby increasing its consumption. In oil exporting countries, the results show that there is no significant effect of financial development. This is because the focus of the financial industry may be on backing the oil sector rather than investing in clean energy.

The economic size and pump gasoline to crude oil prices have positive but insignificant effect on renewable energy consumption in both oil importing and exporting countries.

3. Causality Test

We will finally use the Dumitrescu and Hurlin (2012) panel causality test, which is robust to cross sectional dependence (Baloch et al., 2021), to analyze the causal links that may exist between uncertainty, financial development, and renewable energy consumption in both the ARDL and NARDL model. The results of the causality test are given below.

Table 10**:** Pairwise Dumitrescu–Hurlin panel causality tests for Oil importing countries

Symmetric causality			Asymmetric causality		
Null hypothesis	Zbar-stat	Prob.	Null hypothesis	Zbar-stat	Prob.
$WUI \nrightarrow REC$	0.46133	0.6446	$WUI^{+} \nrightarrow REC$	7.07490***	1.E-12
$REC \nrightarrow WUI$	3.10726	0.0019	$REC \nrightarrow WUI^{+}$	-0.19416	0.8460
$FD \nrightarrow REC$	3.17719	0.0015	$WUI^{-} \nrightarrow REC$	10.1653***	0.0000
$REC \nrightarrow FD$	3.65889	0.0003	$REC \nrightarrow WUI^{-}$	0.22933	0.8186
$ES \nrightarrow REC$	9.47777	0.0000	$FD \nrightarrow REC$	3.17719***	0.0015
$REC \nrightarrow ES$	1.49445	0.1351	$REC \nrightarrow FD$	3.65889***	0.0003
$PGPI \nrightarrow REC$	-0.2903	0.7716	$WUI^{+} \nrightarrow FD$	9.31270***	0.0000
$REC \nrightarrow PGPI$	-0.8277	0.4078	$FD \nrightarrow WUI^{+}$	3.55705***	0.0004
$WUI \nrightarrow FD$	1.20329	0.2289	$WUI^{-} \nrightarrow FD$	7.45147***	9.E-14
$FD \nrightarrow WUI$	2.79568	0.0052	$FD \nrightarrow WUI^{-}$	-0.74009	0.4592
$ES \nrightarrow FD$	4.17498	3.E-05	$WUI^{+} \nrightarrow WUI^{-}$	103.065***	0.0000
$FD \nrightarrow ES$	1.79936	0.0720	$WUI^{-} \nrightarrow WUI^{+}$	3.01784***	0.0025
$PGPI \nrightarrow FD$	1.76682	0.0773	$PGPI \nrightarrow REC$	0.75032	0.4531
$FD \nrightarrow PGPI$	4.84571	1.E-06	$REC \nrightarrow PGPI$	0.44845	0.6538
$ES \nrightarrow WUI$	5.82147	6.E-09	$ES \nrightarrow REC$	9.47772***	0.0000
$WUI \nrightarrow ES$	0.54775	0.5839	$REC \nrightarrow ES$	1.49445	0.1351
$PGPI \nrightarrow WUI$	0.11039	0.9121	$PGPI \nrightarrow FD$	0.78181	0.4343
$WUI \nrightarrow PGPI$	-0.4317	0.6660	$FD \nrightarrow PGPI$	4.24445***	2.E-05
$PGPI \nrightarrow ES$	-0.4521	0.6511	$ES \nrightarrow FD$	4.59921***	4.E-06
$ES \nrightarrow PGPI$	2.34394	0.0191	$FD \nrightarrow ES$	2.45992***	0.0139
			$ES \nrightarrow WUI^{+}$	4.39836***	1.E-05

			$WUI^{+} \nrightarrow ES$	3.73871***	0.0002
			$PGPI \nrightarrow WUI^{+}$	0.02776	0.9779
			$WUI^{+} \nrightarrow PGPI$	0.75737	0.4488
			$ES \nrightarrow WUI^{-}$	4.56376***	5.E-06
			$WUI^{+} \nrightarrow ES$	4.47255***	8.E-06
			$PGPI \nrightarrow WUI^{-}$	-0.53954	0.5895
			$WUI^{-} \nrightarrow PGPI$	0.62112	0.5345
			$PGPI \nrightarrow ES$	-0.23379	0.8152
			$ES \nrightarrow PGPI$	2.14477	0.0320

$\nrightarrow$ denotes no causality, *** denotes significance at 1%

Table 10 shows the linear (ARDL) and non-linear (NARDL) granger causality outcomes, and the asymmetric estimate shows a one-way causality running from uncertainty to renewable energy consumption in the non-linear model at the significance of 1%. This result is in line with the past literature that uses a similar index (economic policy uncertainty), as acknowledged by Adedoyin and Zakari (2020), and lately in line with the results of Lei, et. al. (2021) conducted for China. Furthermore, in both the symmetric and asymmetric models, our results show that financial development causes the transition to renewable energy at a significance level of 1%. It also shows that Renewable energy consumption causes a transition to financial development at the 1% level thus revealing a bidirectional causality.

Table 11**:** Pairwise Dumitrescu–Hurlin panel causality tests for Oil exporting countries

Symmetric causality			Asymmetric causality		
Null hypothesis	Zbar-stat	Prob.	Null hypothesis	Zbar-stat	Prob.
$WUI \nrightarrow REC$	0.25939	0.7953	$WUI^{+} \nrightarrow REC$	3.13394***	0.0017
$REC \nrightarrow WUI$	-0.1692	0.8656	$REC \nrightarrow WUI^{+}$	0.83494	0.4038
$FD \nrightarrow REC$	-0.1196	0.9047	$WUI^{-} \nrightarrow REC$	3.70295***	0.0002
$REC \nrightarrow FD$	1.09886	0.2718	$REC \nrightarrow WUI^{-}$	0.00150	0.9988
$ES \nrightarrow REC$	4.76328	2.E-06	$FD \nrightarrow REC$	-0.11969	0.9047
$REC \nrightarrow ES$	8.86797	0.0000	$REC \nrightarrow FD$	1.09886	0.2718
$PGPI \nrightarrow REC$	-0.4824	0.6295	$WUI^{+} \nrightarrow FD$	4.45290***	8.E-06
$REC \nrightarrow PGPI$	2.70042	0.0069	$FD \nrightarrow WUI^{+}$	2.84876***	0.0044
$WUI \nrightarrow FD$	-0.5683	0.5698	$WUI^{-} \nrightarrow FD$	3.79316***	0.0001

$FD \nrightarrow WUI$	3.58811	0.0003	$FD \nrightarrow WUI^{-}$	0.65812	0.5105
$ES \nrightarrow FD$	3.68676	0.0002	$WUI^{+} \nrightarrow WUI^{-}$	80.6063***	0.0000
$FD \nrightarrow ES$	1.85180	0.0641	$WUI^{-} \nrightarrow WUI^{+}$	4.95480***	7.E-07
$PGPI \nrightarrow FD$	1.16643	0.2434	$PGPI \nrightarrow REC$	-0.48241	0.6295
$FD \nrightarrow PGPI$	1.02783	0.3040	$REC \nrightarrow PGPI$	2.70042***	0.0069
$ES \nrightarrow WUI$	3.85415	0.0001	$ES \nrightarrow REC$	4.76328***	2.E-06
$WUI \nrightarrow ES$	6.96278	3.E-12	$REC \nrightarrow ES$	8.86797***	0.0000
$PGPI \nrightarrow WUI$	0.41642	0.6771	$PGPI \nrightarrow FD$	1.16643	0.2434
$WUI \nrightarrow PGPI$	-0.0857	0.9317	$FD \nrightarrow PGPI$	1.02783	0.3040
$PGPI \nrightarrow ES$	9.35268	0.0000	$ES \nrightarrow FD$	3.68676***	0.0002
$ES \nrightarrow PGPI$	-0.4066	0.6843	$FD \nrightarrow ES$	1.85180	0.0641
			$ES \nrightarrow WUI^{+}$	5.93646***	3.E-09
			$WUI^{+} \nrightarrow ES$	9.31276***	0.0000
			$PGPI \nrightarrow WUI^{+}$	-1.02740	0.3042
			$WUI^{+} \nrightarrow PGPI$	-1.10530	0.2690
			$ES \nrightarrow WUI^{-}$	4.16997***	3.E-05
			$WUI^{+} \nrightarrow ES$	5.31752***	1.E-07
			$PGPI \nrightarrow WUI^{-}$	-1.04631	0.2954
			$WUI^{-} \nrightarrow PGPI$	-0.21837	0.8271
			$PGPI \nrightarrow ES$	9.35268***	0.0000
			$ES \nrightarrow PGPI$	-0.40662	0.6843

$\nrightarrow$ denotes no causality, *** denotes significance at 1%

The results for the oil exporting countries shows that in the asymmetric model, there is a unidirectional causality from uncertainty to renewable energy consumption. The results show that there is no causality between financial development and renewable energy consumption.

CHAPTER VI

ROBUSTNESS TEST

To make sure our results are robust and to avoid the problem of omitted variable bias, we will increase the number of variables by incorporating commodity terms of trade in the regression and run it through different models. Commodity terms of trade affect the costs and availability of renewable energy technologies which can in turn affect the development and adoption of renewable energy. The Commodity terms of trade is derived from the IMF data source. We will also apply an ARDL (although it's worth noting that the efficiency of the ARDL decreases as more variables are incorporated due to problems such as overfitting, and the small sample size of the data) as well as a DOLS model to study and compare the long run effects of uncertainty and Financial development on renewable energy consumption.

Table 12**:** ARDL and DOLS results for Oil Importing countries

Model Selection method: Bayesian Schwartz criteria for ARDL

	ARDL			**DOLS**	
	Coefficient	t-Statistic		Coefficient	t-statistic
Panel A: long run estimates					
FD	-0.2155***	-2.738	DFD	-0.2262*	-1.831
WUI	0.0647*	1.7279	DWUI	0.0518**	2.1057
ES	0.0006***	6.937	DES	0.0001	1.0750
$PGPI$	2.3E-05	1.209	DPGPI	3.36E-05	0.9162
CTT	-0.0008	-1.013	DCTT	0.0006	0.5349

*, **, *** denote significance at the 10%, 5%, and 1% level

As seen from the results in table 12, the DOLS model predicts similar results to the ARDL model we computed earlier. Furthermore, the magnitude of the coefficients for Financial development and Uncertainty are relatively close even with the addition of the commodity terms of trade into the equation.

Table 13: ARDL and DOLS long run results for Oil Exporting countries

Model Selection method: Bayesian Schwartz criteria for ARDL

	ARDL			**DOLS**	
	Coefficient	t-Statistic		Coefficient	t-statistic
Panel A: long run estimates					
FD	-0.0075	-0.9863	DFD	0.0280	0.4521
WUI	0.0135***	2.9351	DWUI	0.0237**	1.7668
ES	0.0001***	6.778	DES	1.E-03**	1.2049
$PGPI$	-8.5E-06	-1.125	DPGPI	7.03E-05	-0.8507
CTT	-0.0002***	-4.975	DCTT	-0.0003	-1.1216

*, **, *** denote significance at the 10%, 5%, and 1% level

After running 19 models using the Bayesian Schwartz criteria, the best model chosen was a (6,1,1,1,1,1). As seen from the table above, the results of the DOLS are similar in direction to that of the ARDL. These results show more evidence to support the robustness of our model.

CHAPTER VII
CONCLUSION AND POLICY RECCOMENDATIONS

This paper examined the dynamic impact of fundamental variables such as uncertainty and Financial development on renewable energy consumption in oil-importing and exporting MENA countries. The NARDL PMG panel framework and Dumitrescu–Hurlin panel causality tests were employed to analyze the long and short-run cointegration results and causality links, using panel data ranging from 1990-2020 for 18 countries. The study has revealed interesting and new results and provides clear implications for policymakers to transition to clean energy.

First, the study shows that in oil-importing countries, a positive shock in uncertainty leads to a negative effect on renewable energy consumption in the long run. Uncertainty in the oil importing market can lead to volatility and risk, which can discourage long-term investment in renewable energy projects, and therefore a positive shock may heighten uncertainty and reduce the confidence of the investor. In the oil-exporting market both the negative and positive shock in uncertainty cause a negative effect on renewable energy consumption. A negative shock to uncertainty may occur if there is sudden and unexpected volatility in the market such as a global recession, and in such events, investors and businesses could become hesitant to invest in clean energy due to the perceived increased risk.

Secondly, the results show that in the long run, Financial development negatively affects renewable energy consumption in oil-importing countries while having no effect in oil-exporting countries. In oil-importing countries, greater financial development may encourage a stronger emphasis on conventional energy sources like oil and gas rather than renewable energy. This is because banks and investors, who seek secure investments with established infrastructure and high demand, view oil and gas as a safer investment choice. Additionally, financial development can lead to more investment competition, creating a more difficult funding environment for renewable energy projects. Consequently, securing capital for renewable energy projects can become challenging, resulting in limited access to funding and difficulty in implementing such projects. Conversely, economies in oil-exporting countries may heavily rely on oil and gas exports, leading financial institutions to prioritize investing in conventional energy over renewable energy. Hence, increased financial development may not significantly impact renewable energy consumption in these nations. Nevertheless, certain oil exporting countries have adopted measures to encourage renewable energy development, like investing in infrastructure or providing subsidies for renewable energy projects. These policies can counterbalance the adverse effects of financial development on renewable energy consumption. In the short run, a positive shock to uncertainty has a positive and significant effect on renewable consumption in oil-importing countries but no effect in oil-exporting countries, whereas a negative shock has no effect in both. The results also show that financial development has a significant positive effect on importing countries but no effect on exporting countries.

Thirdly, the Pairwise Dumitrescu–Hurlin panel causality tests were employed to study the existence and direction of causality among variables. The causality test results display that uncertainty has a unidirectional causality with renewable energy consumption in both importing and exporting countries, while financial development has a bidirectional causality in importing countries and no causality in exporting countries.

As a consequence, policymakers should adopt different policies regarding oil-importing and exporting countries. For oil-importing countries, as recommended by Nguyen (2022), countries should continue to implement financial market reforms towards efficiency, as the financial market should give priority to environmentally friendly investments. Secondly, the government is recommended to issue green bonds to finance renewable energy projects. Green bonds are specifically earmarked for financing environmentally friendly projects and can provide a low-cost source of financing for renewable energy infrastructure. Thirdly, governments should introduce renewable energy certificates, which represent proof that a certain amount of renewable energy has been produced. These certificates can be bought and sold on the open market, providing an additional revenue stream for renewable energy producers. Fourthly, governments should also introduce energy efficiency standards, for vehicles, appliances, and buildings which can help reduce energy consumption and incentivize the adoption of renewable energy sources.

For oil-exporting countries, governments should offer subsidies for renewable energy production and investment to help diversify their economy and reduce their dependence on oil exports. Secondly, governments should invest in research and development of renewable energy technologies to improve efficiency and reduce costs, making renewable energy more competitive with traditional energy sources. Thirdly, Oil-exporting countries can form partnerships with other countries or international organizations to promote renewable energy development and share expertise and resources. Finally, Governments can introduce a carbon pricing mechanism, such as a carbon tax or cap-and-trade system, to incentivize the use of renewable energy and reduce greenhouse gas emissions.

The successful implementation of various policies to promote clean energy investment in the MENA region will require improvement in institutional, political, and financial factors. Institutional reforms to fight corruption, reduce the power of lobbyists, improving political stability, reducing bureaucracy, improving democratic quality, and protecting property rights are crucial. Good governance is important to promote high-cost investments. Policymakers in the MENA region should implement financial, monetary, and environmental policies through legislation to encourage the development of financial systems that support clean energy investments. Governments should provide incentives to establish financial institutions that meet sustainability criteria, including creating green funds. Overall, these actions are necessary to facilitate substitution between polluting and clean energy in the MENA countries.

APPENDIX I

The following summarizes the features of existing institutional databases for gasoline prices in terms of country coverage, time dimension, and data frequency (Kpodar et. al, 2017).

1) **GIZ database**
2) **IEA database**. It covers 33 OECD member countries with quarterly data from 1978 through 2014 on end-consumer prices for various energy products, including gasoline and diesel. The database also compiles prices for industries and provides data on import costs and taxes on energy products. In addition, for a small subset of countries, the IEA releases monthly data (starting from 2005) on gasoline, diesel, heating oil, and fuel oil prices and their applicable taxes.
3) **EC database.** With the aim to improve transparency of fuel prices in the 28 countries of the European Union (EU), the EC has published weekly retail fuel prices and associated taxes with the breakdown in different taxes (VAT, excise, other indirect taxes) since 2009.
4) **ECLAC database**. Covering 11 countries in Latin America, this database compiles information on prices for various petroleum products (regular and premium gasoline, diesel, kerosene, fuel oil, LPG), as well as the composition of prices (import prices, taxes, gross margin) on an annual basis since 2001. Interestingly, the database also provides information on government revenue from taxation of fuel products.
5) **Bloomberg database**. It compiles quarterly gasoline prices for 61 countries, mainly advanced and emerging countries, since 2013 and provides rankings by average price, affordability (measured by the average day's wages needed to buy

a gallon/liter of fuel), and the expenditure share of gasoline spending (portion of annual income spent on total gas purchases).

Aside from these institutional databases, few studies have gathered retail fuel prices data to address specific research questions. For instance, Coady et al. (2010) compile a database on end-of-period retail fuel prices (gasoline, diesel, kerosene) from 2003 to 2008 for a large number of countries (186) to analyze pass-through levels and estimate the magnitude and trends in fuel subsidies. Kpodar and Abdallah (2020) provide an update of the database by extending the time dimension through December 2016.

APPENDIX II

Table 14: Oil importing countries Cross sectional short run coefficients

Egypt

Variable	Coefficient	Std. Error	t-Statistic	Prob. *
COINTEQ01	0.006575	0.000425	15.45691	0.0006
D(WUI_POS)	0.006497	0.000929	6.995351	0.0060
D(WUI_NEG)	0.014538	0.001179	12.33378	0.0011
D(FD)	0.007483	0.005617	1.332290	0.2749
D(GDP_2015PPP)	0.000296	3.61E-08	8183.481	0.0000
D(PGPI)	1.57E-05	4.06E-09	3863.874	0.0000
C	-0.004342	3.67E-05	-118.1846	0.0000

Israel

Variable	Coefficient	Std. Error	t-Statistic	Prob. *
COINTEQ01	-0.060632	0.000204	-296.7175	0.0000
D(WUI_POS)	0.000754	3.92E-05	19.22630	0.0003
D(WUI_NEG)	0.009185	3.73E-05	246.3579	0.0000
D(FD)	0.008639	8.91E-05	96.94248	0.0000
D(GDP_2015PPP)	-0.000183	5.53E-09	-33182.02	0.0000
D(PGPI)	1.16E-06	1.12E-11	103601.1	0.0000
C	-0.001218	5.18E-06	-234.8877	0.0000

jordan

Variable	Coefficient	Std. Error	t-Statistic	Prob. *
COINTEQ01	-0.068995	0.001592	-43.33726	0.0000
D(WUI_POS)	-0.015352	0.000183	-83.87994	0.0000
D(WUI_NEG)	-0.000688	0.000113	-6.097033	0.0089
D(FD)	0.027676	0.000455	60.79706	0.0000
D(GDP_2015PPP)	-7.96E-05	1.12E-08	-7087.428	0.0000
D(PGPI)	1.15E-05	1.18E-10	97564.44	0.0000
C	0.004888	4.04E-06	1209.183	0.0000

Lebanon

Variable	Coefficient	Std. Error	t-Statistic	Prob. *
COINTEQ01	-0.060413	0.002681	-22.53738	0.0002
D(WUI_POS)	0.002602	2.47E-05	105.4242	0.0000
D(WUI_NEG)	0.007793	2.67E-05	291.9064	0.0000
D(FD)	0.008889	0.000821	10.82990	0.0017
D(GDP_2015PPP)	-0.000111	1.75E-08	-6382.522	0.0000
D(PGPI)	8.85E-06	1.67E-10	53111.39	0.0000
C	0.003144	4.61E-06	681.8092	0.0000

Mauritania

Variable	Coefficient	Std. Error	t-Statistic	Prob. *
COINTEQ01	0.016233	9.36E-05	173.4596	0.0000
D(WUI_POS)	-0.001724	4.25E-06	-405.5739	0.0000
D(WUI_NEG)	0.001578	4.02E-06	392.6344	0.0000
D(FD)	-0.007160	2.09E-05	-342.9448	0.0000
D(GDP_2015PPP)	6.72E-05	7.37E-09	9126.055	0.0000
D(PGPI)	7.56E-07	5.40E-13	1401315.	0.0000
C	0.000107	3.26E-08	3268.316	0.0000

Morocco

Variable	Coefficient	Std. Error	t-Statistic	Prob. *
COINTEQ01	-0.426562	0.033889	-12.58708	0.0011
D(WUI_POS)	0.074397	0.001044	71.29568	0.0000
D(WUI_NEG)	-0.036552	0.001028	-35.55631	0.0000
D(FD)	0.071877	0.006155	11.67758	0.0013
D(GDP_2015PPP)	0.000239	3.06E-08	7820.204	0.0000
D(PGPI)	-1.27E-05	2.04E-10	-61924.88	0.0000
C	-0.022714	0.000157	-144.9083	0.0000

Sudan

Variable	Coefficient	Std. Error	t-Statistic	Prob. *
COINTEQ01	-0.001271	0.001423	-0.893487	0.4374
D(WUI_POS)	0.061226	0.000235	260.1096	0.0000
D(WUI_NEG)	-0.049356	0.001165	-42.37385	0.0000
D(FD)	-0.024581	0.008426	-2.917399	0.0616
D(GDP_2015PPP)	0.000138	5.81E-08	2368.422	0.0000
D(PGPI)	-9.61E-06	1.70E-10	-56620.53	0.0000
C	-0.001933	4.14E-06	-467.2273	0.0000

Tunisia

Variable	Coefficient	Std. Error	t-Statistic	Prob. *
COINTEQ01	0.033891	0.000463	73.24778	0.0000
D(WUI_POS)	-0.001731	1.68E-06	-1032.897	0.0000
D(WUI_NEG)	8.45E-05	5.92E-06	14.26217	0.0007
D(FD)	0.005879	0.000189	31.03153	0.0001
D(GDP_2015PPP)	0.000104	3.31E-09	31427.89	0.0000
D(PGPI)	-5.07E-06	4.05E-12	-1251434.	0.0000
C	0.000263	3.83E-07	685.4873	0.0000

Turkey

Variable	Coefficient	Std. Error	t-Statistic	Prob. *
COINTEQ01	-0.264833	0.018234	-14.52430	0.0007
D(WUI_POS)	0.018842	0.040680	0.463176	0.6748
D(WUI_NEG)	0.107359	0.033552	3.199799	0.0493
D(FD)	0.055451	0.409701	0.135346	0.9009
D(GDP_2015PPP)	0.000107	9.22E-08	1157.800	0.0000
D(PGPI)	0.000307	2.73E-08	11246.40	0.0000
C	-0.044478	0.002043	-21.76982	0.0002

Table 15: Oil exporting countries Cross sectional short run coefficients

Algeria

Variable	Coefficient	Std. Error	t-Statistic	Prob. *
COINTEQ01	-0.466532	0.016524	-28.23432	0.0001
D(WUI_POS)	0.015833	4.00E-05	396.2487	0.0000
D(WUI_NEG)	0.014204	6.92E-05	205.3299	0.0000
D(FD)	-0.238475	0.010095	-23.62389	0.0002
D(GDP__2015PPP_)	7.79E-05	5.19E-09	15014.09	0.0000
D(TG)	1.34E-08	8.96E-11	149.0059	0.0000
C	-0.005532	6.31E-06	-876.2003	0.0000

Kuwait

Variable	Coefficient	Std. Error	t-Statistic	Prob. *
COINTEQ01	-0.006414	4.78E-06	-1341.948	0.0000
D(WUI_POS)	0.000511	6.81E-08	7509.856	0.0000
D(WUI_NEG)	-0.000226	4.04E-08	-5587.545	0.0000
D(FD)	-4.41E-06	1.76E-08	-250.5669	0.0000
D(GDP__2015PPP_)	-6.04E-07	6.74E-13	-895486.5	0.0000
D(TG)	-2.07E-07	7.23E-14	-2866801.	0.0000
C	-9.68E-05	1.51E-09	-63922.08	0.0000

Iran

Variable	Coefficient	Std. Error	t-Statistic	Prob. *
COINTEQ01	-0.360340	0.021250	-16.95715	0.0004
D(WUI_POS)	0.042989	0.007232	5.944233	0.0095
D(WUI_NEG)	-0.064399	0.005368	-11.99620	0.0012
D(FD)	-0.043614	0.047997	-0.908675	0.4305
D(GDP__2015PPP_)	0.000236	2.44E-08	9683.385	0.0000
D(TG)	5.20E-05	1.15E-08	4515.118	0.0000
C	0.018896	0.000217	86.95922	0.0000

Libya

Variable	Coefficient	Std. Error	t-Statistic	Prob. *
COINTEQ01	-0.036509	0.000216	-169.3331	0.0000
D(WUI_POS)	0.000353	3.59E-06	98.43914	0.0000
D(WUI_NEG)	-0.000127	1.99E-06	-63.87245	0.0000
D(FD)	-0.002412	6.43E-05	-37.51588	0.0000
D(GDP__2015PPP_)	-1.36E-06	1.31E-12	-1033238.	0.0000
D(TG)	1.44E-06	4.09E-12	350862.4	0.0000
C	-0.000234	7.55E-08	-3103.118	0.0000

Saudi Arabia

Variable	Coefficient	Std. Error	t-Statistic	Prob. *
COINTEQ01	-0.031807	0.000368	-86.40410	0.0000
D(WUI_POS)	0.004312	1.53E-05	282.4048	0.0000
D(WUI_NEG)	-0.003498	1.71E-05	-204.6968	0.0000
D(FD)	-0.005551	1.78E-05	-312.6804	0.0000
D(GDP__2015PPP_)	-7.84E-06	8.10E-12	-967860.9	0.0000
D(TG)	-8.35E-06	3.67E-11	-227472.9	0.0000
C	-0.000476	2.09E-07	-2282.739	0.0000

Bahrain

Variable	Coefficient	Std. Error	t-Statistic	Prob. *
COINTEQ01	0.003362	5.06E-05	66.39790	0.0000
D(WUI_POS)	0.000224	1.37E-06	163.5538	0.0000
D(WUI_NEG)	-0.001383	1.36E-06	-1015.717	0.0000
D(FD)	-0.001961	4.07E-06	-482.1409	0.0000
D(GDP__2015PPP_)	-1.22E-05	2.90E-09	-4200.253	0.0000
D(TG)	9.61E-07	5.73E-12	167540.6	0.0000
C	7.93E-05	4.54E-08	1744.986	0.0000

UAE

Variable	Coefficient	Std. Error	t-Statistic	Prob. *
COINTEQ01	-0.115068	0.007179	-16.02779	0.0005
D(WUI_POS)	-0.009991	0.000289	-34.54290	0.0001
D(WUI_NEG)	0.001314	0.000237	5.549860	0.0115
D(FD)	-0.008600	0.000430	-20.01277	0.0003
D(GDP__2015PPP_)	-0.000111	2.86E-09	-38938.41	0.0000
D(TG)	1.20E-05	8.51E-10	14081.05	0.0000
C	-0.002549	2.07E-05	-123.3647	0.0000

Qatar

Variable	Coefficient	Std. Error	t-Statistic	Prob. *
COINTEQ01	-0.004586	1.15E-05	-397.3778	0.0000
D(WUI_POS)	0.000426	3.31E-07	1284.987	0.0000
D(WUI_NEG)	-0.000273	2.12E-07	-1287.745	0.0000
D(FD)	-0.001111	2.52E-07	-4400.301	0.0000
D(GDP__2015PPP_)	-1.15E-06	8.96E-12	-128097.2	0.0000
D(TG)	4.57E-07	1.21E-12	378703.9	0.0000
C	-0.000180	3.32E-08	-5422.138	0.0000

yemen

Variable	Coefficient	Std. Error	t-Statistic	Prob. *
COINTEQ01	-0.012669	0.000107	-117.8947	0.0000
D(WUI_POS)	0.000693	1.20E-06	579.1943	0.0000
D(WUI_NEG)	0.000194	9.04E-07	214.8091	0.0000
D(FD)	0.044742	0.000124	362.2714	0.0000
D(GDP__2015PPP_)	-1.83E-05	6.84E-11	-267201.4	0.0000
D(TG)	-3.55E-06	2.45E-12	-1445843.	0.0000
C	-0.000259	1.30E-07	-1988.266	0.0000

APPENDIX III

We can separate the Financial development to Financial Markets and Financial institutions and test both separately to specifically address the main components.

The results for Oil importing countries is show below:

Table 16: ARDL and NARDL results for Financial Markets in Oil Importing countries

Model Selection method: Bayesian Schwartz criteria

	ARDL Coefficient	Std. error	t-Statistic	NARDL Coefficient	Std. error	t-statistic
Panel A: long run estimates						
FM	-0.2604**	0.1241	-2.0978	-0.1062**	0.0492	-2.1579
WUI	-0.1258**	0.0604	-2.0834			
WUI^+				-0.0659**	0.0324	-2.0197
WUI^-				-0.0391	0.0344	-1.1346
ES	0.0006***	0.0002	3.6813	0.0006***	7.5E-05	7.4635
$PGPI$	4.02E-05	3.9E-05	1.0132	2.4E-05	1.6E-05	1.5201
Panel B: short run estimates						
$CointegrationEq.$	-0.0526**	0.02667	-1.9724	-0.1057*	0.0601	-1.7593
$D(FM)$	-1.3322	1.3288	-1.0024	-0.9472	0.9377	-1.0101
$D(WUI)$	0.0154**	0.0079	1.9516			
$D(WUI^+)$				0.0127	0.0116	1.0910
$D(WUI^-)$				0.0044	0.0147	0.2982
$D(ES)$	3.04E-05	8.33E-05	0.3649	4.8E-05	5.1E-05	0.9411
$D(PGPI)$	3.37E-05	3.12E-05	1.0800	3.50E-05	3.43E-05	1.0207
$Constant$	-0.0035	0.0032	-1.1039	-0.0064	0.0041	-1.5837

*, **, *** denote significance at/near the 10%, 5%, and 1% level.

Table 17: ARDL and NARDL results for Financial Institutions in Oil-Importing countries

Model Selection method: Bayesian Schwartz criteria

	ARDL Coefficient	Std. error	t-Statistic	NARDL Coefficient	Std. error	t-statistic
Panel A: long run estimates						
FI	-0.0638	0.0836	-0.7636	0.8422	19.0118	0.0443
WUI	0.0286	0.0261	1.0971			
WUI^+				-10.503	234.773	-0.0447
WUI^-				-6.4336	143.668	-0.0447

ES	0.0005***	9.62E-05	5.3792	0.0515	1.15195	0.0447
$PGPI$	5.84E-05**	2.49E-05	2.3423	0.0071	0.15839	0.04448
Panel B: short run estimates						
$CointegrationEq.$	-0.1019**	0.0491	-2.0791	-0.0006	0.0004	-1.3517
$D(FI)$	0.0965	0.0712	1.3549	0.14	0.0874	1.6124
$D(WUI)$	0.0095**	0.0054	1.7694			
$D(WUI^{+})$				0.0207***	0.0079	2.6166
$D(WUI^{-})$				0.0163	0.0204	0.7984
$D(ES)$	1.07E-05	6.25E-05	0.1715	0.0001	5.67E-05	1.7641
$D(PGPI)$	3.29E-05	3.2E-05	1.0305	4.41E-05	4.67E-05	0.9436
$Constant$	-0.0094	0.0058	-1.618	-0.0066	0.0032	-2.0460

*, **, *** denote significance at/near the 10%, 5%, and 1% level

Table 18: ARDL and NARDL results for Financial Markets in Oil Exporting countries

Model Selection method: Bayesian Schwartz criteria

	ARDL Coefficient	Std. error	t-Statistic	NARDL Coefficient	Std. error	t-statistic
Panel A: long run estimates						
FM	0.0304*	0.019	1.598	0.0926*	0.0563	-1.6442
WUI	0.0042*	0.002	1.522			
WUI^{+}				-0.0258*	0.0144	-1.7937
WUI^{-}				-0.0058	0.0138	-0.4264
ES	4.8E-05***	9.35E-06	5.1106	0.0012***	4.08E-05	2.9665
$PGPI$	1.8E-05***	5.54E-06	3.2425	8.81E-06	1.66E-05	0.5306
Panel B: short run estimates						
$CointegrationEq.$	-0.1324*	0.0797	-1.6615	-0.1303*	0.0733	-1.7761
D(REC (-1))	0.2277*	0.1214	1.8758	0.2056*	0.1083	1.8984
$D(FM)$	-0.0111	0.0083	-1.3432	-0.00176	0.0015	-0.1675
$D(WUI)$	-0.0043	0.0030	-1.4156			
$D(WUI^{+})$				0.0056*	0.0031	1.7855
$D(WUI^{-})$				-0.011	0.0076	-1.558
$D(ES)$	2.75E-05	2.34E-05	1.1746	1.27E-05	1.88E-05	0.6741
$D(PGPI)$	4.21E-06	5.47E-06	0.7690	5.09E-06	6.41E-06	0.7938
$Constant$	0.00078	0.00314	0.2471	0.0014	0.00234	0.6021

*, **, *** denote significance at/near the 10%, 5%, and 1% level

Table 19: ARDL and NARDL results for Financial Institutions in Oil-Exporting countries

Model Selection method: Bayesian Schwartz criteria

	ARDL Coefficient	Std. error	t-Statistic	NARDL Coefficient	Std. error	t-statistic
Panel A: long run estimates						

FI	-0.00986**	0.0039	-2.5134	-0.1076**	0.0515	-2.0865
WUI	0.00263	0.0025	1.0498			
WUI^{+}				-0.0479	0.0508	-0.9430
WUI^{-}				-0.1946**	0.1000	-1.9456
ES	6.5E-06***	2.52E-06	2.8996	-9.18E-06	2.99E-05	-0.3071
$PGPI$	-4.01E-07	5.15E-06	-0.077	0.00018	0.00011	1.6673
Panel B: short run estimates						
$CointegrationEq.$	0.0026	0.0930	0.0278	-0.0634*	0.0399	-1.59
$D(FI)$	-0.1209	0.0808	-1.496	-0.053*	0.0325	1.6363
$D(WUI)$	-0.0033	0.0026	-1.278			
$D(WUI^{+})$				0.0089	0.0078	1.1456
$D(WUI^{-})$				-0.0073	0.0071	-1.021
$D(ES)$	2.55E-05	2.23E-05	1.1437	1.96E-05	2.79E-05	0.702
$D(PGPI)$	6.52E-07	3.21E-06	0.2028	1.04E-06	2.31E-06	0.4497
$Constant$	0.0031	0.0030	1.0168	-0.0022	0.0017	-1.3035

*, **, *** denote significance at/near the 10%, 5%, and 1% level.

APPENDIX IV

Table 20: Summary Financial development, Uncertainty and REC Nexus

Financial development

Author	**Period**	**Country/ region**	**Method**	**Result**
Brunnschweiler (2010)	1980-2006	119 non-OECD countries	GLS and Dynamic panel data estimations	Financial intermediation, in particular commercial banking, has a significant positive effect on the amount of RE produced. Bigger impact with non-hydropower RE such as wind, solar, geothermal and biomass.
Wu and Broadstock (2015)	1990-2010	22 emerging markets countries	Dynamic panel model estimation techniques (GMM)	financial development and institutional quality positively and significantly affects renewable energy consumption
Best (2017)	1998-2013	137 countries	Cross-section analysis (OLS), static panel model estimation techniques (FE)	Financial capital helps in the transition from fossil fuel to modern renewable energy sources
Burakov and Freidin (2017)	1990-2014	Russia	Vector error correction model and Granger causality test	No causality found between Financial development and renewable energy consumption
Kutan et al. (2018)	1990-2012	Brazil, China, India, and South Africa	Group-Mean FMOLS panel data model estimation and Panel causality test	FDI inflows and stock market development significantly affect renewable energy consumption
BM Eren, N Taspinar, K K Gokmenoglu (2019)	1971-2015	India	Dynamic ordinary least squares (DOLS) estimation	There is a significant and positive impact of economic growth and financial development on renewable energy consumption
SG Anton, AEA Nucu (2020)	1990-2015	28 Countries in the European Union	Panel Fixed effect model	Financial development has a positive effect on the share of renewable energy consumption
A Lahiani, S Mefteh-Wali, M Shahbaz,	1975-2019	USA	NARDL	In SR, only negative changes of overall and stock-based financial development measures significantly impact renewable energy consumption.

XV Vo (2021)				
J Wang, S Zhang, Q Zhang (2021)	1997-2017	China	ARDL-PMG model	LR relationship indicate that for China as a whole and western China, economic growth stimulates renewable energy consumption while financial development impacts it negatively. In SR, economic growth and financial development influence renewable energy consumption negatively and positively, respectively.
S Muktarov, S Yüksel, H Dinçer (2022)	1980-2019	Turkey	VECM and ARDL techniques	Financial development has a positive and statistically significant influence on renewable energy consumption
SK Dimnwobi, CV Madichie, C Ekesiobi, SA Asongu (2022)	1981-2019	Nigeria	ARDL	Financial development has a critical and positive effect on renewable energy consumption
W Lei, L Liu, M Hafeez, S Sohail (2022)	1990-2019	China	nonlinear ARDL	Financial development does not matter in renewable energy consumption in China
Nguyen (2022)	1990-2020	Vietnam, Indonesia, Malaysia, Thailand, and the Philippines and China, Korea, and Japan.	Generalized least square method	Increase in financial development yields a negative effect on renewable energy consumption. Furthermore, economic growth and lending rates have no effect on renewable energy in the East and Southeast Asian countries

A Samour, MM Baskaya, T Tursoy (2022)	1989-2019	UAE	Bootstrap autoregressive distributed lag	Financial development, *FDI*, and economic growth can significantly increase renewable energy consumption in the UAE
Le Thanh Ha	1992-2019	Vietnam	Variate wavelet model	A partial phase difference between FD and renewable energy consumption (from 1994 to 2008) suggests the anti-phase relation with the rise of renewable consumption.

Uncertainty

Author	**Period**	**Country/region**	**Method**	**Result**
Reboredo and Wen (2015)		China	GARCH specification	Pre- and post-announcement energy legislation policies dampened price volatility in all subsector indexes and that economic incentives had a positive policy announcement effect on all subsector index prices.
Sohail et al. (2021)	1985-2019	USA	NARDL	Monetary economic policy had short and long run negative effects on renewable energy consumption in the linear model, while decreasing monetary uncertainty has a significant negative effect on renewable energy consumption in the non-linear model.
Lei et al. (2021)	1990-2019	China	NARDL	Results show that positive change in economic policy uncertainty has increased 3.216% and negative change in economic policy uncertainty has decreased 1.461% in renewable energy consumption in long run in China. Financial development does not matter in renewable energy consumption in China
Zeng et. al (2021)	1991-2019	BRICS countries	NARDL-PMG	A positive shock in economic policy uncertainty exerts a negative impact on renewable energy consumption. However, a negative shock in economic policy uncertainty has a positive impact on renewable energy consumption.

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