The Connectedness of the Housing Market, Energy Market and Agricultural Commodities in the United States

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ABSTRACT

In the first part of this dissertation, we investigate the dynamic response of renewable energy consumption to long-run and short-run impact of agricultural land usage for the period 1995-2014 in sixteen Coastline Mediterranean Countries (CMC-16). For this reason, a dynamic Autoregressive Distributed Lag (ARDL) approach is employed in a multivariate framework such that carbon emission and GDP are employed as additional variables in the model. With a speed of adjustment of 19.6% from short-run disequilibrium to long-run, the respective panel impacts of the real gross domestic product per capita and agricultural land are 16.31 (positive) and 0.78 (negative) in the long-run. Importantly, there is empirical evidence and significant short-run impact of agricultural land usage on renewable shares in total energy consumption in seven (7) of the CMC-16. Also, Granger causality evidence from carbon emission and GDP to renewable energy are all with feedbacks. However, Granger causality from agricultural land usage to renewable energy is without feedback. In the region, effective policy implementations through the collaborative effort of stakeholders will ensure a sustainable renewable energy development amidst agricultural activities.

Proceeding further, rather the housing construction policy vis-à-vis dwellings, building and residential developments is incorporated to examine its impact on the renewable shares in total energy consumption in Spain, France, Slovenia, Greece, Turkey, Lebanon and Israel. The dynamic heterogeneous Pooled Mean Group approach is adopted for the investigation over a period of 1999 to 2015 with real gross domestic product per capita and the carbon emission being employed as additional variables. While a statistically significant and negative long-run impact is observed from the housing construction policy (3.73) and carbon emission (2.01), the impact of the real GDP is statistically significant and positive (0.00079). The panel will significantly adjust to long-run equilibrium under an unforeseen disturbance at a moderate annual speed of about 45.8%. The inference from the cross-section and short-run indicates that only in Israel is the housing construction policy having a significant impact on the renewable shares in total energy consumption. However, a feedback of Granger causality is significant from carbon emission to the renewables and the housing construction policy.

Moreover, the response (using the Markov switching model) of renewable energy equity to prices of corn, soybean and wheat for the period 20/01/2012 - 2/08/2018 for the United States is investigated. Given the statistically significant evidence of switching parameters, we found positive impacts of soybean and wheat on the renewable energy equity in both the stable and recession regimes while the impact is negative in the regimes for corn. The positive impact of soybean is an indication that the share of renewable energy and share of its export is highest while corn has recently been preferred for food rather than a source of renewable energy.

Lastly, this research considers the measurement of return and volatility spillovers among the United States market components: renewable equity, Crude oil WTI and Brent (energy market), REIT (the housing market), and the wheat, corn and Soybeans (agricultural commodities). Using the novel approach of Diebold and Yilmaz (2012) for the sample period January 20, 2012 to August 2, 2018, the findings suggest the following empirical regularities. First, although low in magnitude, there is return and volatility shock transmissions among the components of the markets (housing market, energy market, and the agricultural commodities). Second, among the market components, the total net volatility spillovers is higher than the total net returns. Lastly, with a smaller sample size, the total net vitality spillovers is higher than the investigated full sample size. Moreover, our investigation further reveals significant evidence of pairwise directional volatility spillovers.

Keywords: Renewable Energy, Housing Market, Agricultural Commodities, Carbon Emission, ARDL model; Markov Switch Model, Diebold and Yilmaz Approach.

ÖZ

Bu tezin ilk bölümünde, 16 kıyı şeridi Akdeniz ülkelerinde (CMC-16) yenilenebilir enerji tüketiminin, turizm geliştirme ve tarımsal arazi kullanımının kısa ve uzun dönemli etkilerine olan dinamik tepkisini 1995- 2014 dönemi için incelenmiştir. Çalışmada, karbon emisyonunun ve GSYH'nin kontrol değişkeni olarak kullanıldığı çok değişkenli ve iki modelli bir çerçevede, dinamik Otoregresif Dağıtılmış Gecikme Modeli (ARDL) yaklaşımı uygulanmıştır. Kısa dönemdeki dengesizlikten uzun dönem dengesine kadar %19,6 'lık bir ayarlama hızı ile, kişi başına düşen gayri safi yurtiçi hasıla ve tarım arazisinin uzun dönem panel etkileri sırasıyla 16.31 (pozitif) ve 0.78 (negatif) bulunmuştur. Ampirik bulgular, CMC-16'nın 9'unun kısa vadeli bir faktör olarak turizm gelişimine sahip olduğunu gösterirken, Slovenya ve Kıbrıs'ın kısa vadeli ortak bir faktör sergilediğini göstermektedir. Ayrıca, karbon emisyonu, GSYİH ve turizm geliştirme ile yenilenebilir enerji arasında geri beslemeye dayalı Granger nedensellik ilişkisi bulunmuştur. Bununla birlikte, tarım arazisi kullanımı ile yenilenebilir enerji arasında geri beslemeye dayalı Granger nedensellik ilişkisi bulunmamıştır. Bölgede, paydaşların iş birliğine dayalı çabalarıyla etkin politika uygulamaları, tarım ve turizm faaliyetlerinde sürdürülebilir yenilenebilir enerji gelişimini sağlayacaktır.

Ayrıca; konut, bina ve konut gelişmelerine yönelik konut inşaatı politikasının İspanya, Fransa, Slovenya, Yunanistan, Türkiye, Lübnan ve İsrail'deki yenilenebilir enerji tüketimine olan etkisi incelenmiştir. Bu çalışmada, Dinamik heterojen Havuzlanmış Ortalama Grup yaklaşımı benimsenerek 1999-2015 dönemine ait veri setine ilave olarak kişi başına düşen gayri safi yurtiçi hasıla ve karbon emisyonu serisi kullanılmıştır. Volatilite endeksi (esneklik katsayısı 0.126) ve karbon emisyonu

(esneklik katsayısı 0.751)'nun uzun dönem etkisi istatiksel olarak anlamlı ve pozitif iken, konut politikasının (esneklik katsayısı 0.308) etkisi negatif bulunmuştur. Panel ülkelerinin öngörülemeyen sapma altında, ortalama yıllık yüzde 45,8 uyarlama hızıyla uzun dönemli dengeye ulaşacağı bulunmuştur. Yatay-kesit ve kısa dönemden elde edilen sonuç, sadece Lübnan'da konut inşaatı politikasının yenilenebilir enerji kaynaklarının önemli bir belirleyicisi olmadığını göstermektedir. Bununla birlikte, karbon emisyonu ile yenilenebilir enerji ve konut inşaat politikası arasında geri beslemeli Granger nedensellik ilişkisi bulunmuştur.

Ayrıca, Amerika Birleşik Devletleri'nde 20/01/2012-2/08/2018 dönemi için mısır, soya fasulyesi ve buğday fiyatlarına göre yenilenebilir enerji kaynağı rejim çıkarımını (Markov değişim modelini kullanarak) inceledik. İstatiksel olarak anlamlı değişim bulgularıyla, her iki rejimde soya fasulyesi ve buğdayın yenilenebilir enerji kaynağı üzerinde pozitif etkisi bulunurken, mısırın yenilenebilir enerji eşitliği üzerinde negatif etkisi olduğu bulunmuştur. Bu aynı zamanda, yenilenebilir enerji payının ve soya fasulyesi ihracatının payının en yüksek olduğunu göstermektedir, çünkü mısır yenilenebilir enerji kaynağı yerine gıda için tercih edilmiştir.

Son olarak, Amerika Birleşik Devletleri pazar bileşenleri arasında geri dönüş ve volatilite yayılımı ölçümlerini inceliyoruz: yenilenebilir enerji, ham petrol WTI ve Brent (enerji piyasası), GYO (konut piyasası) ve buğday, mısır ve soya fasulyesi (tarımsal ürünler). 20 Ocak 2012 - 2 Ağustos 2018 dönemi için, Diebold ve Yılmaz'ın (2012) yeni yaklaşımını kullanarak elde ettiğimiz bulgular sırasıyla ampirik düzeli ilişkileri işaret etmektedir. Birincisi, düşük büyüklükte olmasına rağmen, piyasa bileşenleri (konut piyasası, enerji piyasası ve tarımsal ürünler) arasında geri dönüş ve volatilite şok aktarımı vardır. İkincisi, piyasa bileşenleri arasında, toplam net volatilite yayılımı toplam net getirilerden daha yüksektir. Son olarak, daha küçük örneklem

büyüklüğü ile, toplam net volatilite yayılımı incelenen tam örnek bıı daha yüksektir. Buna ek olarak, araştırmamız istatiksel olarak anlamlı çift yönlü yönlü volatilite yayılmalarına dair kanıtları ortaya koymaktadır.

Anahtar Kelimeler: Yenilenebilir Enerji, Konut piyasası, Tarımsal Emtialar, Turizm, Karbon salınımı, ARDL modeli, Markov Değişim Modeli, Diebold ve Yılmaz Yaklaşımı.

DEDICATION

To Snr. Instructor **Ulaş Gökçe**

Through the platform of Eastern Mediterranean University,

You're used by God to advance my dreams.

My wife and I love you!

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AIC	Akaike Information Criteria
ALD	Agricultural Land Usage
AR	Assessment Report
ARDL	Autoregressive Distributed Lag
AVS	Agrivoltaic Systems
BP	British Petroleum
CEM	Carbon Emission
CMC	Coastline Mediterranean Countries
CO_2	Carbon Dioxide
EIA	Energy Information Administration
EU	European Union
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GMM	Generalized Methods of Moment
HPI	House Price Index
IPCC	Intergovernmental Panel on Climate Change
IEA	International Energy Agency
RE	Renewable Energy
REC	Renewable Energy Consumption
RES	Renewable Energy Source
OECD	Organization for Economic Cooperation and Development
PMG	Pooled Mean Group
PVPs	Photovoltaic Panels

TPES	Total Primary Energy Sources
UNFCCC	United Nations Framework Convention on Climate Change
WDI	World Development Indicators

Chapter 1

INTRODUCTION

The importance of the housing sector, energy sector, and the agricultural sector to the global economy, makes the study of the interactions of the markets more appealing. Considering that the aforementioned sectors are characterized of the major land-based production sectors, the interaction of the sectors is a close reflection of the Global Biomass Optimization Model (GLOBIOM)[1]. Moreover, the model has been employed in literature to assess land-use (direct and indirect), biofuels, and macroeconomic factors. (Havlík et al., 2011; Böttcher et al., 2012; Ermolieva et al, 2015). In examining the environmental (such as carbon emission) and land utilization component of renewable energy on one hand, the cost factor (financial) component of renewable energy are expectedly encompassed in GLOBIOM. Importantly, within the concept of macroeconomics, empirical evidence has shown inter-market interactions among world's economies (Forbes & Chinn, 2004). For instance, a number of hypotheses in literature have examined the dynamic information transfer among the markets and the connectedness of the markets (Steeley, 2006; Kal, Arslaner & Arslaner, 2015; Tsai, 2015; Basher & Sadorsky, 2016; Antonakakis & Floros, 2016; Massacci, 2016; Lee & Lee, 2018).

In addition to the aforementioned components of the GLOBIOM, agricultural commodities and carbon credit are have continued to constitute the different sectoral

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[1] The GLOBIOM is used to analyze the competition for land use between agriculture, forestry, and bioenergy. It is a model designed by the International Institute for Applied Systems and Analysis. Further detail is available at http://www.globiom.org/.

portfolios of the financial market. For instance, the increasing competitiveness of agricultural commodity prices is not unconnected with the persistent global drive toward achieving a safer environment. As such, this has continued to encourage the development of the agricultural-based energy source. On the other hand, the environmental cost of economic expansion which formed the basis for carbon credit has continued cause global surge in the number of emissions trading systems (European Commission, 2018). Consequently, recent technologies have continued to harness the potential of Carbon Capture and Utilization (CCU) or the Carbon Capture Sequestration (CCS) in the framework of developing renewable energy source from CO_2 emissions (Koytsoumpa, Bergins & Kakaras, 2017).

Importantly, the resulting dynamics of the market components of the GLOBIOM is similar to the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) by Robinson et al (2015). In this study, an improved IMPACT model incorporates the housing market, renewable energy, and the agricultural commodities in lieu of macroeconomic trends, climate models and crop models respectively (see Appendix A). As such, the housing market, the renewable energy, and the agricultural commodities interacts as a Multi-market Model of IMPACT global. In investigating the market dynamics, the components of the examined markets are considered. For instance, the renewable energy, buildings and residential construction, and the trio of corn, soybeans and wheat are the respective components of energy, the housing, and agricultural sectors. While the dynamics of renewable energy consumption is examined using the Coastline Mediterranean Countries (CMC) as a case study, the US is employed to study the connectedness of the energy, the housing, and the agricultural markets. The CMC is not preferred to examining the connectedness of the markets because of data restriction. Hence, the US is favourably considered giving the magnitude of the country's economic market, the potential global economic impact, and data availability.

Moreover, a preliminary investigation in chapter two suggests the determinants of the renewable energy consumption (Evans et al., 2009). The study considers a panel of sixteen (16) CMC, and found that the use of agricultural land in the region is an important factor in determining the renewable shares of total energy consumption. Agricultural land is considered because of it obvious impact on the environment and the ecological structure. Also, the renewable energy source from agricultural products, especially the crop plants have continued to gain more attention in recent decade. As a novel contribution, the study examine the impact of agricultural practices, especially the use of land (Ajanovic, 2011; Murphy, 2011) and the tourism development (Kelly & Williams, 2007; Kuo & Chen, 2009; Frantál & Urbánková, 2017; Isik, Dogru & Turk, 2018) on the renewable energy consumption.

An extension of the earlier study is presented in chapter three. In this case, and using the conventional Autoregressive Distributed Lag (ARDL) model, the study examines the impact of carbon emissions and housing policy on the renewable energy consumption. In the process of land exploration or utilization (for instance, for housing and agricultural practices), more carbon emission is naturally expected, thus reducing the potential for renewable energy source. On the other hand, recent carbon harvesting technologies (such as the CCU or the CCS) have continued to provide alternative to environmental pollution as well and as well utilized for developing renewable energy source. Hence, the study considered seven selected CMC in the panel investigation. The contribution of the study is that the housing construction policy of the panel countries potentially determines the availability of renewable energy sources (Cheng, Liu, Brown & Searle, 2018; Arshad & Routray, 2018).

Furthermore, using the non-linear Markov-switch approach, the relationship between the renewable energy and agricultural commodities especially in the US is examined. Considering the aforesaid interactions of the markets, this study in essence underpins the relationship with specific emphasis on the financial market of the indicated commodities. In doing so, the study examines the regime switching of renewable energy equity (in two regimes) in respect to the agricultural prices of soybean, corn, and wheat. Sigificantly, the indication is that the impacts of the commodities is a possible predictor of the share of renewable energy equity.

Lastly, this chapter incorporates the components of the markets to further examine their potential interactions. In doing so, the spillovers among the housing market, energy market, and the agricultural commodities using the Diebold and Yilmaz (2012 is examined. Hence, the renewable energy equity, Crude oil West Texas Intermediate (WTI) and Brent (energy market), Real Estate Investment Trust (REIT) (the housing market), and the wheat, corn and Soybeans (agricultural commodities) were considered. The study potentially investigate the return and volatility shock transmissions among the components of the markets (housing market, energy market, and the agricultural commodities).

Chapter 2

THE IMPACT OF AGRICULTURAL LAND USAGE ON RENEWABLE ENERGY CONSUMPTION AMONG THE COASTLINE MEDITERRANEAN COUNTRIES

2.1 Introduction

Progressive studies within the framework of renewable energy have consistently added to the literature and toward guiding policymakers and researchers on the pathway to clean and sustainable energy, and amidst sustainable economic development. The International Energy Agency (IEA) and other energy-related agencies indicates that investing in energy efficiency is capable of increasing global economic output by $18 trillion dollars which is more than the combined outputs of the United States, Canada, and Mexico (World Energy Outlook-IEA 2016). Similarly, ExxonMobil report (Outlook for Energy 2017) also enumerated the importance of energy to economic growth. Their report predicts that the next 15 years will see middle class more than double thus pacing-up energy consumption with more people expected to have access to energy-powered facilities. Apergis and Payne (2010) studied a panel of nine South American countries using a multivariate framework of panel cointegration and error correction models over the period of 1980-2005. The study revealed evidence of long-run relationship between real GDP, energy consumption and real gross fixed capital formation. Other studies of energy consumption in some selected regions are further documented (Mahadevan & Asafu-Adjaye, 2007; Apergis

& Payne, 2009; Bartleet & Gounder, 2010); Menyah & Wolde-Rufael, 2010; Ozturk, Aslan & Kalyoncu, 2010).

Generally, energy has been conceived to have a positive driving momentum on economic growth, the lingering concern over recent years has drastically shifted to the speed of transition to a more secure, effective and cleaner source of energy vis-à-vis renewable energy sources. The United States Energy Information Administration (EIA) simply referred renewable energy as the energy type that regenerates, unlike the fossil fuels that are finite. It corroborated that the five types of renewable energy include biomass (biodiesel, ethanol, landfill gas, solid waste gas and wood waste), hydropower, geothermal, wind and solar.[2] There have been renewed calls for more development of a renewable type of energy, low carbon, and other alternatives and efficient sources of energy have consistently being advocated (Figueres et al., 2017; Goldthau, 2017). Likewise, studies indicate that renewable energy constitutes a relatively small proportion of the total energy globally (Sadorsky, 2009). The study by Sadorsky (2009) detailed the relationship between oil prices, $C0_2$ emissions and renewable energy consumption of the G7 countries. The per capita renewable energy consumption is observed to be driven by increases in both the real GDP per capita and $C0_2$ per capita. Also, Apergis and Payne (2010) observed a long-run relationship between real GDP, real gross fixed capital formation, labour force, and renewable energy consumption. Their further study found both short-and long-run bidirectional causality between renewable energy consumption and economic growth among Eurasian countries (Apergis and Payne, 2010) and carbon emission (Menyah and Wolde-Rufael, 2010). Interestingly, using a multivariate panel technique on 27

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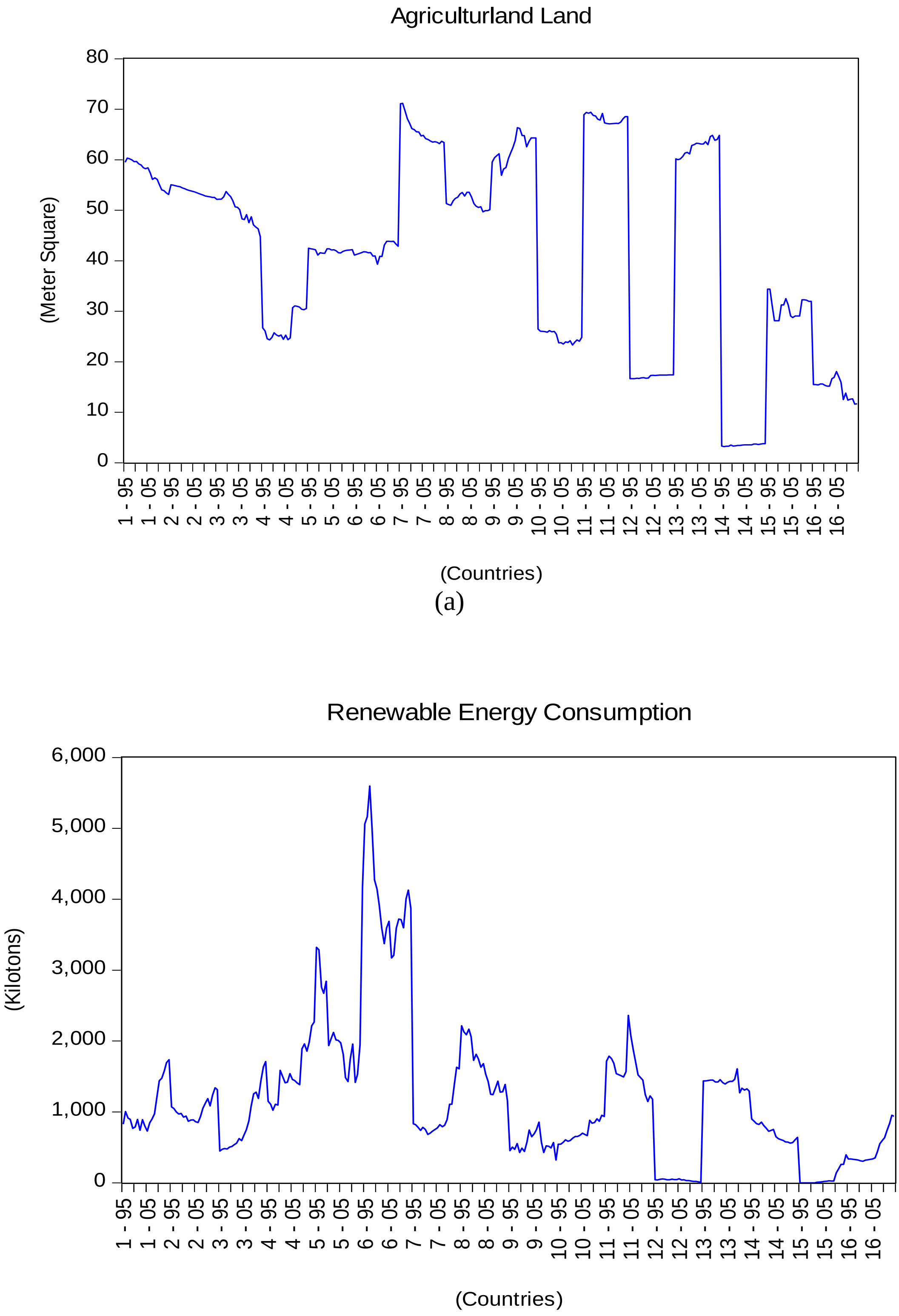
[2] The U.S. Energy Information Administration (EIA) provides an independent statistics and analysis of the energy sector in the United State of America. Information regarding the sources of energy, their outlook and projections of renewable energy is made available. https://www.eia.gov/energyexplained/?page=renewable_home.

European countries, Menegaki (2011) noted a lack of causality evidence between GDP and renewable energy consumption among the observed 27 European countries which is assumed to be partly caused by the inadequate and unequal development of renewable energy sources across the continent. In retrospect, many countries of the world, including the coastline Mediterranean are fast adopting the policies aimed at attaining cleaner energy and economic sustainability. For instance, in a recent move, the French government (one of the EU-28 and coastline Mediterranean country) announced on 6 July 2017 its plan to ban or end the sales of petrol and diesel vehicles by 2040.

While studying renewable energy-mix with specific relation to the land use of the Polish province Kujawsko–Pomorskie Voivodship, Sliz-Szkliniarz (2013) notably expressed that trade-off is potentially accounted for in renewable energy and land use interaction. The justification for this interaction is that every energy production process (specifically RES) affects the environment and places a demand on land resources. On the basis that renewable energy systems are land intensive (Calvert & Mabee, 2015), several recent studies (Uyan, 2013; Tahri, Hakdaoui & Maanan, 2015; Calvert & Mabee, 2015 respectively for cases of Turkey, Morocco and Canada) are directed at implementations that maximizes the availability and productivity of land resources. Similarly, the study of renewable energy technologies in Eastern Ontario of Canada by Calvert & Mabee (2015) is an additional guide to the framework of this study. The study noted the competition of solar and biomass technologies for the available “marginal and abandoned agricultural land”.

However, the studies that relate renewable energy sources and production in respect to land use as mentioned above mostly fell short of empirical analysis. Hence, the novelty of this study is to empirically understand the nexus of agricultural land usage, and renewable energy consumption (REC). Also, in this framework, studies on the Mediterranean region and specifically the coastline Mediterranean countries have barely been conducted. Leaning on the theoretical ideas of Tilman et. al., (2009) which addresses arable land-RES interplay and Tsagarakis et al. (2011) and Dalton Lockington and Baldock (2007, 2008) which discussed the attitudinal impact of tourists on RES, this study aimed to empirically answer contextual questions. Firstly, if the study empirically predicts the impact of agricultural land usage on REC, then the question of ‘how much of the agricultural land is needed for specific RES consumption’ is an answered one. In the same context, the short run and long-run equilibrium relationship between these variables are investigated in the study. As such, significant evidence of short-run and long-run equilibrium with the pair is illustrated. And lastly, empirical evidence of Granger causality further support the linkages.

The study presents a panel data analysis using an Autoregressive Distributed Lag (ARDL) specification that reveals the long run and short-run relationship between renewable energy consumption and agricultural development in addition to carbon emission. In investigating this panel of sixteen coastline Mediterranean countries (CMC-16); Albania, Algeria, Bosnia and Herzegovina, Cyprus, Egypt, France, Greece, Israel, Italy, Lebanon, Malta, Morocco, Slovenia, Spain, Tunisia and Turkey spanning from 1995 to 2014, empirical evidence of causality is further presented. A visual observation and characteristics of the renewable energy consumption and agricultural land usage is presented in Figure 1.



(a)

(b)

Figure 1: The Agricultural Land (a) and (rec) Renewable Shares in Total Energy Consumption (b) Series Plots.

The rest of the study is structured as follows. Section 2 highlights existing studies and trends of linkages between agricultural land usage and renewable energy consumption while Section 3 covers data description and empirical methodologies. The empirical findings and implications for policy are reported in Section 4. Concluding remarks are provided in Section 5.

2.2 Agricultural land: A Nexus of Renewable Energy Production

Across the globe, there has been a continuous increase in the development of renewable energy sources. A good number of RES are crop and plant-based, as such, what ensured is the food, energy and environment trilemma (Tilman et. al., 2009). The idea of possible competition for land use between food and energy productions was conceptualized in the 1970s. From that period and the pioneering work of Brazil's Proa´lcool, the use of biofuel, solar and wind as energy sources for transportation, industrial production, residential lightings, and among others is fast increasing (EIA, 2018). In the current year 2018, British Petroleum (BP) energy outlook report indicates a growth of over 400% in renewable energy that accounts for over 50% increase in global power generation (BP, 2018). Such report affirms previous literature that suggested the increasing development of renewable energy sources and such directly or indirectly trigger demand for land use. Evidently, Ajanovic (2011) reiterated this competitive dynamics between food production and biofuel. The study specifically noted that the main feedstock which comprises of corn, wheat, barley, sugarcane, rapeseed, and soybeans are used for biofuels production. In avoiding impending food insecurity, research is fast developing and considering a switch-over to the second generation and third generation biofuels[3] which is primarily based on lignocellulosic

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[3] For readers, detail information, analysis of biofuel generation and projections amidst the competitive nature of land was highlighted by Murphy et. al (2011).

feedstocks (Murphy, Woods, Black & McManus, 2011). In their study, Murphy et. al (2011) hinged the research question on the implicative linkage between competition for land and biofuels. As such, and regarding Europe, the study opined that Europe continues to enjoy moderate crop yield which has obviously translated to a decline in an arable land across Europe. Observing a paradigm shift from the traditional land usage for food production to crop production as sources for biofuels, the emergence of agro-energy has significantly altered the dynamics of land use (Rathmann, Szklo & Schaeffer, 2010). Harvey and Pilgrim (2011) and Nonhebel (2005) are among important contributor to this contextual underpinning of arable land, food and biofuel productions.

Similarly, solar and wind sources of renewable energy have been investigated comprehensively over time. A newly adopted form of agricultural practice, the Agrivoltaic systems (AVS) and was expressed "as mixed systems associating solar panels and crop at the same time on the same land area" (Dupraz, Marrou, Talbot, Dufour, Nogier & Ferard, 2011). This new system is developed as a framework to resolve the competition for land use between food and energy production through the combination of photovoltaic panels (PVPs) and crops on the same land area (Valle et al., 2017). Also, the study mentioned the advantage of using a mobile or dynamic Agrivoltaic concept with the aid of orientable PVPs derived from solar trackers. This is so because increasing land availability and productivity would mean increase renewable energy production (Marrou, Guilioni, Dufour, Dupraz & Wéry, 2013; Calvert & Mabee, 2015; Dinesh & Pearce, 2016). Other uses of land, for example, ecological conservation, tourism and agriculture (Sliz-Szkliniarz, 2013) are subjected to competition for land space with the different option of renewable energy sources. Economic contributions of agriculture in some CMC are evidently important as illustrated in Table B of the appendix which also presents information on the respective proportion of RES generation. For instance, olive oil production (probable source of renewable energy) from the Mediterranean basin: Greece, Italy, Spain, Syria, Tunisia, and Turkey account for about 90 percent of global production. The case of Israel's sophisticated agricultural-irrigation systems, with a continuously increasing land area for agricultural purpose, is a typical illustration of land use trade-off. Agricultural soils across some Mediterranean countries were suspected to possess valuable chemical compositions which are inclusive of heavy metals (Micó et al., 2007). In spite of the terrestrial endowment of the region, the study by Zalidis et al. (2002) reveals the limitations of agricultural exploitations in the region as associated with and affected other development activities. Also, recent evidence has shown that Mediterranean countries are already facing important issues of water stress and extreme climate events which in turn could hamper renewable energy sources in the region. Responsible factors for these include increased tourism development and agricultural activities and such that could exacerbate issues, resulting in significant human and economic losses. Also, worst of these problems for example is observed in wind farms where wind turbines are installed on arable land alongside crop production. The conservation and recreation of such land are adversely impacted due to the effect of the turbines on the esthetics of the landscape and on the sensitivity of ecological areas.

2.3 Data and Estimation Specification

This study employs annual panel data for the CMC-16 (earlier listed above) from 1995 to 2014. The remaining five countries within the context were excluded due to data unavailability. *Agricultural land use* (*ald*) is the percentage of land use for arable, under permanent crops and permanent pastures. *Renewable energy consumption* (*rec*) is the renewable energy consumption in kilotons. *Real Gross*

Domestic Product (*gdp*) in billions of constant 2010 dollars. *Carbon emissions* (*cem*) are measured in kilotons per capita. All the aforementioned variables are collected from the World Development Indicators (WDI, 2017) of the World Bank online database.

2.3.1 Estimation Specification

The studies by Marques, Fuinhas, and Manso (2010) and Aguirre and Ibikunle (2014) painstakingly grouped the determining factors of renewable energy sources as political factors, welfare, socioeconomic factors, energy needs and country-specific factors. Additionally, the study of Omri and Nguyen (2014) modelled renewable energy consumption as a function of carbon emission, real oil price, per capita GDP and trade openness. In a similar pattern, renewable energy consumption is modelled in this study such that *ald* proxy for *country-specific factors* while welfare and environmental factors are respectively proxied by *GDP* and *cem* as shown in equation (1).

$$rec = f\,(\mathrm{cem}, gdp, ald) \tag{1}$$

Also, the long-run relationship of the above expression is determined via the linear logarithmic model which is presented as:

$$rec = \alpha_0 + \alpha_1 \mathrm{logcem} + \alpha_2 \mathrm{loggdp} + \alpha_3 \mathrm{ald} \tag{2}$$

2.3.2 Dynamic ARDL and Granger Causality Test

The advantage of an ARDL model is its applicability for a mixed order of integration which is experienced in the panel unit root estimations shown in Table 1. In an alternative format to GMM, the Pooled Mean Group (PMG) estimation adopts the cointegration form of the ordinary ARDL model as proposed by Pesaran, Shin and Smith (PSS, 1999). It is adopted here such that the panel estimation presents the lag length *q* (which is 2 for the estimated equation 3) as selected by the Akaike Information

Criteria (AIC) for both the regressors and dependent variables. Hence, the PMG method for the panel estimation is expressed as an error correction equation which is presented as:

$$\Delta y_{i,t} = \phi_i EC_{i,t-1} + \sum_{j=0}^{q-1} \beta_{i,t} \Delta X_{i,t-j} + \sum_{j=1}^{p-1} \lambda_{i,j} \Delta y_{i,t-j} + \varepsilon_{i,t} \tag{3}$$

where the error correction $EC_{i,t} = y_{i,t} - X_{i,t}\theta$ is the deviation from the long-run equilibrium, ϕ is the adjustment coefficients (i.e the short-run error correction term that measures the speed of adjustment toward the long-run) and θ is vector of the long-run coefficients such that $X = f$ (log*cem*, log*gdp*, *ald*) in the model. Also, β is a vector of short-run coefficients, $\varepsilon_{i,t}$ is the error term associated with different cross section variance that results from the country-specific effects. Moreover, y is the dependent variable, *rec* (renewable shares in total energy consumption).The estimation output of the model specifications ARDL (1, 2, 2, 2) is shown in Table (2).

Table 1: Panel Unit Root Test

Variable	LLC		IPS		Fisher-ADF	
	c	t	c	t	c	t
rec	3.893	-0.250	5.508	4.462	14.697	19.171
log*gdp*	-6.53252*	-7.96544	-3.08055*	-1.96979**	74.4287*	43.3516
log*cem*	-2.26110**	-1.40209	0.84190	1.92320	35.6553	38.6850
ald	-2.173**	-2.53*	0.037	-1.970**	48.119**	52.923**
Δ*rec*	-10.883*	-12.843*	-8.357*	-9.680*	144.105*	143.248*
Δlog*gdp*	-15.8005*	-11.6562*	-9.19597*	-7.71090*	326.618*	97.1359*
Δlog*cem*	-14.1675*	-16.3626*	-12.2139*	-14.8989*	193.795*	199.492*
Δ*ald*	-9.849*	-7.390*	-10.240*	-8.420*	155.704*	121.225*

Note: *, ** and *** are statistical significance at 1%, 5% and 10% respectively. **Δ** indicates first difference. Lag selection by SIC of maximum of 4 in all estimations. LLC, IPS and Fisher-ADF are the Levin, Lin and Chu (2002); Im, Pesaran and Shin (2003); Fisher-ADF by Maddala & Wu (1999) panel unit root tests.

Table 2: Pooled Mean Group Test with Dynamic ARDL Specifications

		ARDL (1, 2, 2, 2)		
	log*gdp*	log*cem*	*ald*	*Adjustment parameter*
Long-run	1631.104(0.000)*	-1252.741(0.000)*	-0.776(0.000)*	**-0.196(0.000)***
Short-run (Panel)	-1027.505(0.041) **	-754.818(0.015) **	-0.055(0.661)	
Short-run of cross-sections				
1	-367.855(0.099)***	-1485.992(0.991)	-0.518(0.027)**	-0.309(.001)*
2	-2408.627(0.199)	311.823(0.994)	0.190(0.965)	-0.197(0.003)*
3	-1550.039(0.998)	-1495.598(0.927)	0.360(0.000)*	-0.364(0.000)*
4	-1853.536(0.919)	-2356.294(0.983)	0.189(0.006)*	-0.235(0.000)*
5	-6909.319(0.995)	-3695.203(0.868)	-0.249(0.985)	0.003
6	-3402.469(0.946)	-481.357(0.957)	0.168(0.644)	-0.205(0.000) *
7	597.661(0.901)	-450.898(0.991)	0.076(0.511)	-0.112(0.000) *
8	1641.462(0.972)	-2948.860(0.467)	-0.164(0.642)	0.038
9	411.685(0.887)	-531.986(0.676)	0.421(0.000)*	-0.206(0.000) *
10	-351.701(0.985)	-343.774(0.997)	0.017(0.832)	-0.415(0.003) *
11	520.776(0.940)	136.094(0.922)	-1.630(0.096) ***	-0.137(0.022) **
12	-268.930(0.176)	76.727(0.850)	-0.047(0.089)	-0.017(0.003) *
13	-108.677(0.994)	-1779.272(0.997)	-0.035(0.613)	-0.530(0.001) *
14	-434.125(0.699)	-166.121(0.970)	0.590(0.324)	-0.436(0.001) *
15	588.595(0.644)	-135.050(0.187)	0.012(0.037) **	0.073
16	-1568.624(0.130)	56.872(0.998)	-0.266(0.000)*	0.045

Diagnostic test (Cross-sectional Dependence Test, Null hypothesis: Cross Sectional Independence)

Pesaran CD: t-statistics = 0.0718, Probability value = 0.9428, d.f. = 120

Note: *, ** and *** are statistical significance at 1%, 5% & 10 % respectively. ARDL is Autoregressive Distributed Lag while d.f. is the degree of freedom. Number of observations = 288, maximum lag selection by Akaike Information Criteria (AIC) and number of model evaluated is 2.

2.4 Empirical Results and Discussion

Illustration from the unit root results of Table 1 (top) presents a justification for ARDL because of the mixed-order in the stationarity of the variables. The ARDL estimation presents the Error Correction Model (ECM), specifically the coefficient of adjustment from short run to long-run are desirables (see Table 2). It indicates that in any situation of disequilibrium, the model (i.e ARDL 1,2,2,2) adjusts with the speed of 19.6%. In this case, the results further inform that indicates *ald*, *gdp*, and *cem* are all statistically significant determinants of *rec* in the long-run. Here, in the long-run, it present that 1% increase in *gdp* and *cem* will respectively cause 16.31 kilotons increase and 12.52 kilotons decrease in renewable energy consumption respectively. Importantly, a unit increase in *ald* will expectedly cause 0.78 kilotons decrease in renewable energy consumption respectively. The negative relationship between agriculture land and the renewable energy consumption is supported by previously studies which noted the competitiveness of solar and biomass technologies for the available "marginal and abandoned agricultural land or arable land in cases (Valle et al., 2017). Other studies had previously accounted for the association between land availability of land and renewable energy production (see Marrou, Guilioni, Dufour, Dupraz & Wéry, 2013; Calvert & Mabee, 2015; Dinesh & Pearce, 2016). Besides, panel estimate of the short-run relationship shows a statistical significant between *rec* and *gdp*, and *rec* and *cem*. Also, the cross-section short-run estimate (for the CMC-16 countries[4]) is provided in Table 2.

In addition to residual diagnostics and coefficient diagnostic of confidence ellipse of Fig (2 & 3), the estimates shown in Table 3 equally presents Granger

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[4] For Table 2, 1=Spain, 2=France, 3=Italy, 4=Slovenia, 5=Bosnia and Herzegovina, 6=Algeria, 7=Greece, 8=Turkey, 9=Lebanon, 10=Israel, 11=Morocco, 12=Algeria, 13=Tunisia 14=Egypt, 15=Malta, and 16=Cyprus.

causality relationships between the estimated variables. The employed Dumitrescu and Hurlin (2012)[5] test also reveal the predictability of future dynamics using the past event of the estimated variable. This empirical evidence mentioned above adds to the evidence of no cross-sectional dependence as illustrated in the last part of Table 2.

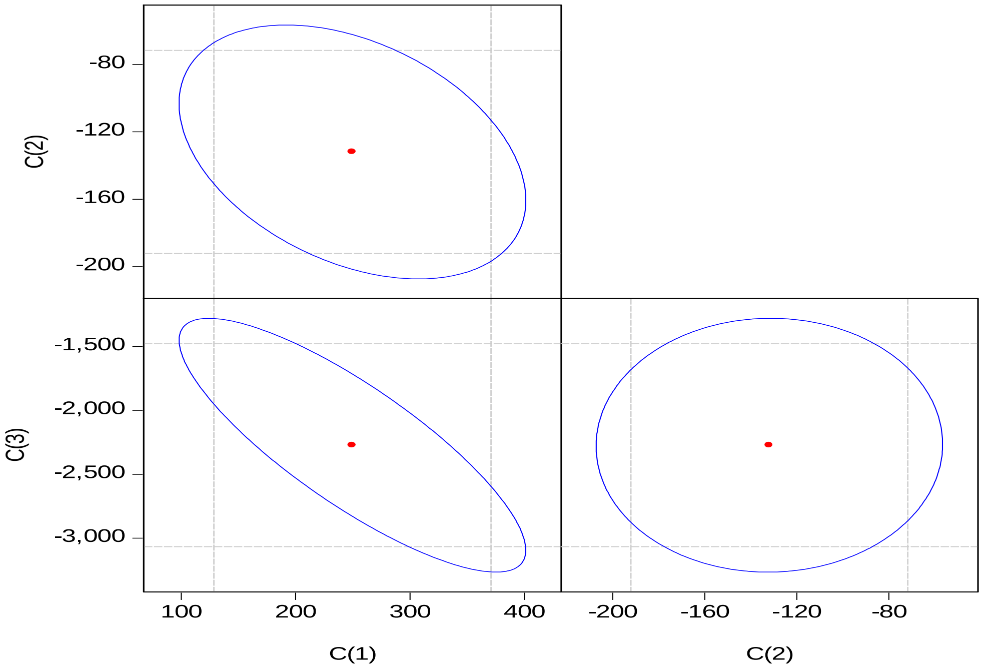

Figure 2: Coefficient Diagnostic with Confidence Ellipse.

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[5] The detail of Granger non causality test hypothesis which is not provided here because of page constraint can be read up in Dumitrescu and Hurlin (2012).

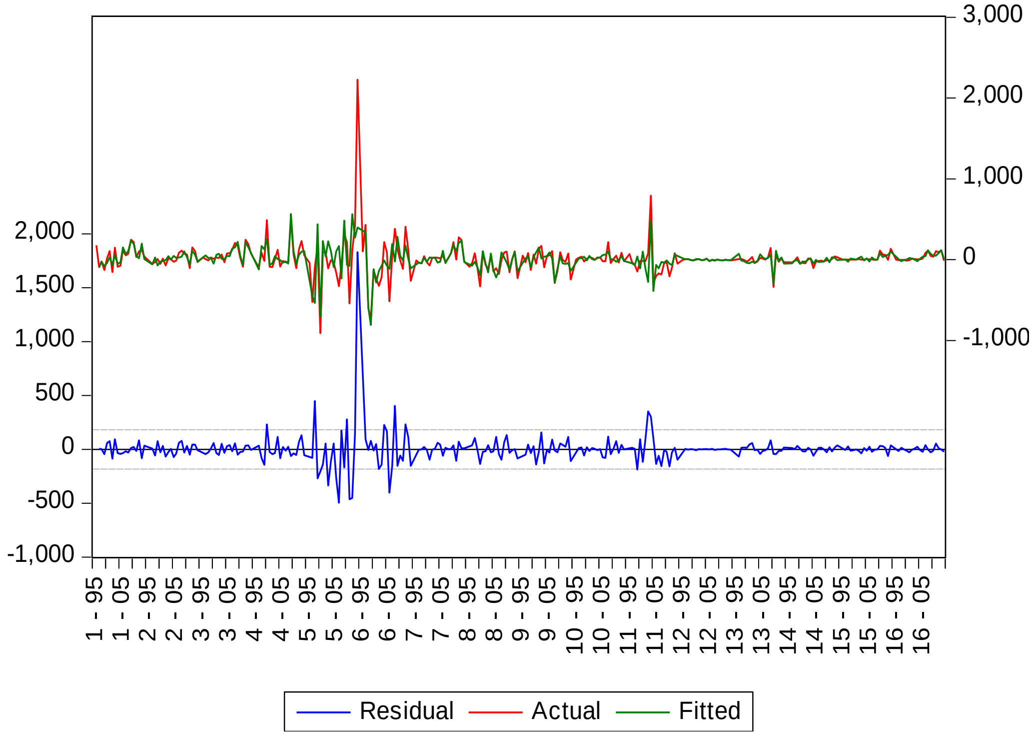

Figure 3: Illustrate the Residual, Actual and Fitted Value Estimates.

Table 3: Panel Granger Causality Results by Dumitrescu and Hurlin (2012)

Null hypothesis	w-stat	$\bar{z}$-stat	*P*-value	Direction
rec→log*gdp*	4.653	3.223	0.001*	
log*gdp*→*rec*	5.384	4.253	2.E-05*	Bi-directional
log*cem*→*rec*	5.076	3.819	0.000*	
rec→log*cem*	6.284	5.520	3.E-08*	Bi-directional
log*cem*→log*gdp*	3.41519	1.48067	0.1387	
log*gdp*→ log*cem*	7.08846	6.65295	3.E-10*	Uni-direction
ald→log*gdp*	6.80822	6.25836	4.E-10*	
log*gdp*→ *ald*	5.01866	3.73849	0.0002*	Bi-directional
ald→log*cem*	6.94054	6.44467	1.E-10*	
log*cem*→*ald*	3.41683	1.48298	0.1381	Uni-direction
ald→*rec*	5.426	4.312	2.E-05*	
rec→ *ald*	2.875	0.20	0.471	Uni-direction

Note: ** and * are statistical significance level at 5% and 1% respectively and it indicates evidence of Granger causality.

The Granger causality results of Table 3 shows causality with feedbacks between *rec* and log*gdp,* logcem and *rec,* and *ald* and log*gdp*. On the other hand, there is Granger causality without feedbacks from ln*cem* to ln*gdp*, from *ald* to ln*cem*, and from *ald* to *rec*. This translate that the previous history of each variable can appropriately suggest the future behavior of another variable.

2.5 Conclusion

This study has focused on providing insights into the relationship between agricultural land usage and renewable energy consumption. Agricultural land usage is observed to have a significant impact on the renewable energy consumption, thus the dynamic relationships is examined. Our findings established a significantly negative relationship between agricultural land usage and renewable energy consumption. This is very consistent with the question “renewable energy and food supply: will there be enough land?” by Nonhebel (2005) and the study of Murphy et. al (2011). A handful of studies have previously considered the land use challenge without considering dynamic relationship (Rathmann, Szklo & Schaeffer (2010); Harvey & Pilgrim (2011); Calvert & Mabee (2015); Dinesh & Pearce, (2016). Additionally, in the cross section, the impact of agricultural land usage on renewable energy consumption (in short-run) is statistically significant in Spain, Italy, Slovenia, Morocco, Malta, and Cyprus.

More importantly, renewable energy source is not largely spread out across the region, the renewable energy consumption is small and increases in the panel countries. Among the panel, Bosnia & Herzegovina, Albania and Slovenia have the three highest contributor of renewable energy as a proportion of its total energy generation (see Table B in appendix). Also, the contribution of agriculture to the economies of the CMC-16 is responsible for the significant and negative long-run relationship which could be due to the depletion and lack or ineffective of utilization of renewable energy sources in the environment resulting from excessive agricultural practices.

Also, a future study could be tailored to addressing the significance of the components of renewable energy sources to the region and by specifics to the member countries of the coastline Mediterranean region.

2.6 Policy Implication

The result of the negative long-run equilibrium relationship between agricultural land usage and renewable energy consumption poses a concern for policymakers. Ideally, production of millions of tons of ethanol-based fuel from crops and plants to meet daily transports, industrial production and service industry demands would expectedly translate to continuous agricultural practices. Considering the long-run result, policymakers and stakeholders in the CMC-16 and by extension to other regions should consider the cultivation of higher-yielding and improved crop seedlings and plants the purpose of land use maximization. For Slovenia and Cyprus with significant impacts in the short run, both agricultural and renewable energy policies of the countries should reflect this available evidence. In designing instruments for RES and agricultural land-use regulation, the essential step is to explore investment possibilities in different contexts considering also the potential for a rise in food prices as opined by Rathmann, Szklo and Schaeffer (2010). Energy support programs from private, non-governmental partnership, and the intergovernmental agencies like the International Renewable Energy Agency are billed to further strengthen the 2020, 2030 and 2050 energy strategy of the European Union. These policy implementations are essential mechanism toward increasing the renewable energy consumption of the CMCs. Hence, the expected challenge of meeting the energy need could be efficiently mitigated as much as there is continuous increase in the renewable energy consumption of the CMC-16 (specifically nine of the examined countries).

Chapter 3

REVISITING RENEWABLE ENERGY CONSUMPTION IN THE COASTLINE MEDITERRANEAN COUNTRIES: MEASURING WITH THE HOUSING CONSTRUCTION POLICY

3.1 Introduction

The United State Energy Information Administration (EIA) mentioned that renewable energy (RE) is the energy type that regenerates, unlike the fossil fuels that are finite (EIA, 2018). The RES are equally considered as clean sources and technologies. It corroborates that the five types of renewable energy includes biomass (biodiesel, ethanol, landfill gas, solid waste gas and wood waste), hydropower, geothermal, wind and solar.[6] Series of climate change and global warming resolutions aiming at tuning down carbon emissions and promoting an alternate energy sources usage, among is the Fifth Assessment Report (AR5) of the United Nation's Intergovernmental Panel on Climate Change (IPCC) and the Paris agreement of 2015[7].

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[6] The U.S. Energy Information Administration (EIA) provides an independent statistics and analysis of the energy sector in the United State of America. Information regarding the sources of energy, their outlook and projections of renewable energy is made available. https://www.eia.gov/energyexplained/?page=renewable_home.

[7] A conference organized by the United Nations Framework Convention on Climate Change (UNFCCC) between 30 November and 12 December 2015 culminates into the Paris climate agreement or Paris climate accord. The legal protocol which was finalized in 2014 was officially activated and became effective on 4 November 2016 and had 195 UNFCCC members signatory to it. https://ec.europa.eu/clima/policies/international/negotiations/paris_en.

These independent agencies have all constituted driving mechanism for renewable energy usage. Also, since an opportunity is been presented of the dire need to meeting the staggering energy demand projection of 25 per cent by 2040, then an expansion in the renewable energy sector is expected (ExxonMobil-Outlook for Energy, 2017). Yet, it is reported that renewable energy constitutes a relatively small proportion of the total energy mix across countries worldwide (Sadorsky, 2009a, b; Rafindadi & Ozturk, 2017; Zhang et al., 2017). Even before the late 2015 Paris meeting, renewable energy is reported in 2014 to have provided an estimated 19.2 per cent (REN21 2016 page 17) final energy consumption which continued in growth and capacity in 2015. By the same year 2015, an estimated 147 gigawatts (GW), the largest annual increase ever of renewable power capacity is reported to have been added amidst the crashing in the global prices of all fossil fuels (REN21 2016 page 17). Despite these challenges, and the relatively high cost of the renewable energy (Zhang et al., 2017; Kardooni, Yusoff, Kari & Moeenizadeh, 2018), global investment is observed to have subsequently increased, economic and private investor activities across sectors also increased, while employment in renewable energy sector increased to 9.4 million jobs (including large-scale hydropower, direct and indirect jobs) within the same year 2015 (REN21 2016 page 17).

The aforementioned economic impacts contribute to the importance of continued research on renewable energy. In that direction, new evidence opined the advantage(s) of the technological approach of conversion and utilization of CO_2 emissions in developing renewable energy source (Rahman et al., 2017). And, in considering efficient energy consumption, stakeholders and governments tend to consider the specificity of energy performance in the construction and allocation of buildings (Rouleau, Gosselin & Blanchet, 2018; Zhang, Kang & Jin, 2018). This, obviously is not without employing strategy at sustaining equitable access to green spaces which is primary to renewable energy generation.

As such, the goal of this study is built on the specifics of renewable energy consumption among the Coastline Mediterranean Countries (CMC) in relation to the region's carbon emission and the housing construction policy vis-à-vis allocation for dwellings and built housing structures amidst uncertainty. Advancing the study of Alola & Alola (2018) and the 'Food-energy-environment trilemma' conceptual study of Wang, Lim & Ouyang (2017), our study further examine the sustainability of the RES consumption in regard to a region's environmental uniqueness. The investigation presents a panel data (orderly comprising of Spain, France, Slovenia, Greece, Turkey, Lebanon and Israel) empirical model that details the linkages between carbon emissions, the housing policy amidst uncertainty factors over the period 1999 to 2015. In view of this, our investigation is designed to reveal:

- The potential of the housing or dwellings allocation policy in determining the region's renewable energy consumption (REC) in both the short and long-run term.
- A joint impact of the housing policy and carbon emissions in relation to REC.

Moreover, the study is aimed at achieving a novel contribution to the extant studies. Firstly, it is novel because it proposed an insight into the sustainability of country's housing construction policy (the allocation of dwellings, buildings and residential constructions in relation to the energy consumption. The CMC region is constraint with land availability (Alola & Alola 2018) amidst the dynamics in population of the settlers as also caused by housing allocation policies (Change, 2018). On a second note, the uniqueness of the CMC region which borders with several Middle East states (considering the volatility nature and the heavy fossil fuel deposits of some Middle

East countries) is also motivating perspective of this study. The essence is to further reveal the source of the region's (or country-by-country) source of renewable energy, i.e. imported or domesticated RES. In doing so, the current investigation provides a reliable information and explanation to the country-wide RES information presented in Table 4.

Table 4: Country Statistics of Renewable Energy Source (RES in MTOE)

RES Country	Hydro	Biofuels and Waste	Wind	Solar	Geothermal	Total (MTOE)
Spain	3.4 (3% of TPES)	6.2 (5.5% of TPES)	4.5 (3.9% of TPES)	2.9 (2.5% of TPES)	- -	17.0 (14.9% of TPES)
France	4.7 (1.9% of TPES)	15.1 (6.1% of TPES)	1.8 (0.7% of TPES)	0.8 (0.3% of TPES)	0.2 (0.1% of TPES)	22.6 (9.2% of TPES)
Slovenia	0.33 (5.0% of TPES)	0.70 (10.6% of TPES)	**Geothermal/Wind/Solar = 0.079** (1.2% of TPES)			1.1 (16.8% of TPES)
Greece	0.5 (2.3% of TPES)	1.4 (6.3% of TPES)	0.4 (1.9% of TPES)	0.5 (2.3% of TPES)	- -	2.9 (12.5% of TPES)
Turkey	5.8 (4.4% of TPES)	3.3 (2.5% of TPES)	1.0 (0.8% of TPES)	1.0 (0.7% of TPES)	4.8 (3.7% of TPES)	15.7 (12.1% of TPES)
Israel	- -	2.3 (2.0% of TPES)	**Geothermal/Wind/Solar = 0.44** (1.9% of TPES)			0.46 (2.0% of TPES)
Lebanon	0.038 (0.5% of TPES)	0.13 (1.7% of TPES)	**Geothermal/Wind/Solar = 0.023** (0.3% of TPES)			0.19 (2.5% of TPES)

Note: MTOE is Million tonnes of oil equivalent and TPES is Total Primary of Energy Supply excluding electricity trade.
Source: Author's computation from the International Energy Agency (IEA).

The remainder of this study paper is organized as follows. Section two gives a background of renewable energy. The third section describes the data and empirical approaches employed while the succeeding (fourth) section discussed the results. The policy implications of the research are discussed in section 5 the concluding remarks and the highlights for further study.

3.2 Literature Review

Unlike the drivers of non-renewable energy types (coal, oil, e.t.c.) which have been studied over a period of time (Nyasha, Gwenhure & Odhiambo, 2016; Niu, Chang, Yang, & Wang, 2017; Martinho, 2018; Zhi-Guo, Cheng & Dong-Ming, 2018), the study of renewable energy consumption is quite a relatively new research endeavor. Obviously, the faster development of the renewable energy cannot be easily separated from the association between energy demand and economic growth and other salient determinants as expressed in extant literature. Earlier, in the study of Apergis and Payne (2010 a), the relationship between REC and economic growth for a panel of twenty Organization for Economic Cooperation and Development (OECD) countries was examined for the period of 1985 to 2005. The study captures all the panel of countries but one (they are all OECD countries except Lebanon) of the current study. In the multivariate framework, the cointegration and error correction model adopted for the investigation establishes a positive long-run equilibrium between the REC, the labour force, real GDP, and real gross fixed capital formation. Also, the study indicates a bidirectional Granger-causality between REC and economic growth in the short and long-run observations. Also, in 11 South American countries, Apergis and Payne (2015) revealed that Gross Domestic Product per capita grow along with renewable energy consumption per capita over the period 1980-2010. Again, Sadorsky (2009b) examined the behaviour of REC and income among selected panel of emerging economies. In the investigation, a significant and positive relationship between real per capita income and per capita renewable energy consumption with a unit percentage change in real per capita income causing a 3.5% impact. Also, specifically for Lebanon which is neither OECD nor European country, Houri (2006) and Kinab and Elkhoury (2012) are among other significant contributions to the investigation of renewable energy consumption in Lebanon.

But the continued development and use of the renewable energy source, conceivably because of rising oil prices and climate change debacle has also geared nations toward attaining energy security. As such, in attaining energy security, research emphasis has continued to be built on efforts at identifying the major determinants of the dynamics of an alternative energy sources. In a recent study of renewable energy in the European Union (EU), Duscha and Del Río (2017) examined the interactions between electricity generations from renewable energy source (RES-E), climate and energy policies. Adopting a qualitative method that uses effectiveness and efficiency of RES-E support as assessment criteria, the study (Duscha & del Río, 2017) examined the performances of the Energy Taxation Directive, EU emissions trading system (EU ETS) and the effort sharing directive in the European Union. Over a decade ago, especially in many oil-dependent countries, the coal, oil and natural gas which are major component of fossil fuel were reported to account for 80% of world energy demand (Sadorsky, 2009a). Furthermore, in a recent study, Wang, Wang, Wei & Li (2018) investigate the determinants of China's renewable energy. The study specifically investigates supply mix, energy security and carbon emissions and as well forecast the relative requirement for the year 2020 and 2030. In their result, energy security is significantly observed to show contribution to renewable energy development (also with new and total renewable energy consumption) and such relationship is observed to be closer compared to other factors. Similarly, and in regard to China, Chen (2018) observed that economic growth, CO_2 emissions, foreign trade and urbanization have heterogeneous effect on renewable energy consumption across the country's provinces. Additionally, on the evidence of dynamics of renewable energy growth, Aguirre and Ibikunle (2014) summarily opined that significant failures in some energy policies design are common factors in the examined countries. The study identifies uncertainty and likelihood of discontinuity as factors causing failure in institutional frameworks and policies, thus impede renewable energy investments and growth.

3.2.1 Carbon Emission and REC: An Environmental Insight

According to Stern (2008), the economic impact of global warming and greenhouse emission could respectively reduce global GDP by about 25% and 1%. The countries of the coastline Mediterranean region are obviously not exempted from the global environmental concern. Also, the region's environmental challenge resulting from its environmental activities is a concern especially to the development of the RES. For instance, Carbon dioxide (CO_2) emissions has been linked to the development in agriculture mechanization and agro-industry (Martinez-Mate et al., 2018; Xu & Lin, 2017 & 2018). Importantly, and for Spain, Martinez-Mate et al. (2018) maintained that renewable energy is capable of mitigating Greenhouse gas (GHG) by 9 per cent in the lettuce production system. Importantly, from wider perspectives, recent studies have continued to show the usefulness of carbon dioxide emissions in the development of renewable energy source for sustainable future. For instance, while acknowledging that CO_2 emissions account for about 77% of greenhouse gases (GHGs) emissions, Rahman et al (2017) revealed the potential of incorporating CO_2 as a feedstock in a carbon capture sequestration (CCS) technology in developing renewable energy source. The study attributes the conversion of CO_2 to biofuels as presented in the investigation as a best practice that provides a solution to pollution. Similar studies have linked renewable energy to carbon emissions by using the concept of carbon capture technology (Arnette, 2017; Koytsoumpa, Bergins & Kakaras, 2017). In addition, Koytsoumpa, Bergins and Kakaras (2017) assessed the potential of Carbon Capture and Utilization (CCU) in the framework of developing renewable energy source from CO_2 emissions.

3.2.2 Housing Development and REC: A Socio-economic Linkage

Evidence from the global financial crisis of 2008 indicate that the housing or real estate sector is an important segment of most economies of the world (Norris & Byrne, 2018). The fact is that the sector important to the government, non-government agencies, investors, financial institutions, consumers and other stakeholders. The trend of urbanization, implementation of notable reforms in the sector, strategic spatial plans are among factors that account for housing development (Oliveira & Hersperger, 2018). However, the scarcity of land resources, economic constraints, and the danger of potential environmental degradation are some of the key concern associated with the housing construction and allocation. For instance, in Sweden the landownership in the country's municipalities is an important framework that potentially influences the housing allocation policy (Caesar & Kopsch, 2018). Similarly, China introduced a well-managed economic system with limited allocated welfare housing that models a commercial housing market since 1998 (Wu, 2015; Shen, Huang, Li, Li and Zhao, 2018). Beyond indirectly influencing the housing allocation, inadequate proactive planning and improper allocation of land resources are responsible for lack of equitable access to green spaces which is primary to renewable energy generation (Arshad & Routray, 2018). Using ten residential sites in Sheikhupura city of Pakistan, Arshad and

Routray (2018) examined that the country’s housing schemes proffers an equitable access to green space as against large amount of farmland being converted for urban construction as reported by Cheng, Liu, Brown & Searle (2018). Arshad and Routray (2018) further expressed that the provision of urban green infrastructure of the housing scheme system utilizes the green spaces and the dwelling unit and per capita share of the green spaces. This justify the reason China’s housing sector exhibits significant impact on global energy consumption (Zhang, Wu & Liu, 2018). Moreover, the land use efficiency (LUE) approach which is an effective housing allocation policy mitigates the profound challenges of urban planning and risk of regional environmental degradation.

Furthermore, effective housing development and allocation policy are primarily determined by the adoption of modern constructional technologies and production of building materials. In turn, the study by Larionov (2018) indicates that the housing policy in the concept of energy saving and energy efficiency is designed to pre-determine the construction of high-rise residential buildings and other housing and utility services. The study identifies the role of such policy in harmonizing economic interests of the key market players. These interests are contradictions that arise from the motives and economic expectations of both the housing suppliers and end users of the facilities. Also, notably because of cost effectiveness, income differential (low and high income) housing policies are being considered in the provision of the supply of housing and the housing facilities. In their study, McCabe, Pojani and van Groenou (2018) implied that the newly evolving housing association for low-income earners equally provides opportunity for renewable energy installations at reduced social and financial costs end users. Also, in Sweden, owners of rental housing adopt a deep housing renovation policy that do not only encourage renewable energy use, but is aimed at reducing carbon emissions from residential housings (Femenías, Mjörnell & Thuvander, 2018). In European countries like the aforementioned case of Sweden, the European energy policies as noted by Femenías, Mjörnell and Thuvander (2018) are importantly responsible for the housing development frameworks.

3.3 Data and Empirical Approach

In studying a panel of seven selected CMC countries (Spain, France, Slovenia, Greece, Turkey, Lebanon and Israel), annual datasets spanning from 1999 to 2015 were employed. The restriction to seven countries of the region was due to data unavailability especially for the dwellings, buildings and residential construction data. *Renewable energy consumption* (*rec*) is the dependent variable and is measured as the renewable energy consumption in kilotons. The *Total Dwellings and Residential Buildings by Stage of Construction* (*drb*) which proxy for the housing policy (development) is the number of housing construction per annual. *Carbon dioxide* (CO_2) emissions which proxy for carbon emissions are from the burning of fossil fuels (during consumption of solid, liquid, and gas fuels and gas flaring) and the manufacture of cement which is measured in kilotons. Also, the *Real Gross Domestic Product* (*gdp*) in billions of constant 2010 dollars is employed as a control variable (Reboredo, 2015; Dutta, 2017). The variables, *rec, gdp,* and CO_2 datasets are collected from the World Development Indicators (WDI, 2017) of the World Bank online database while *drb* is retrieved from the online database of Federal Reserve Bank of St. Louis. Given the aforesaid information, the model employed is presented as:

$$rec = f\,(\mathrm{CO_2}, drb, gdp) \qquad (1)$$

Similar to the approach of Sadorsky (2009a) and Dutta (2017), equation 1 can be represented in a natural logarithmic form such that all variables are transformed accordingly:

$$rec_{i,t} = \beta_{0,\mathrm{i}} + \beta_1 \log C02_{i,t} + \beta_2 \log drb_{i,t} + \beta_3 \log gdp_{i,t} + \varepsilon_{i,t} \quad (2)$$

where β_0 is the constant of the estimation and $\beta_1, \dots \beta_3$ are the coefficients of the explanatory variables. For all i = 1, … 7 and t = 1999, …2015 which are the cross sections, ε is the error term which are independent and identically distributed with zero mean and constant variance.

3.3.1 Empirical Approach

Before proceeding to the estimation, the stationarity of the variables are examined to avoid having a spurious regression. The test methods employed here the panel unit root tests of Levin, Lin and Chu (2002), Im, Pesaran and Shin (2003) and the Fisher-ADF by Maddala & Wu (1999). The tests null hypotheses (H_0) consider unit root while the alternative hypotheses (H_1) consider stationarity (no unit root). While both Im, Pesaran and Shin (2003) and the Fisher-ADF by Maddala & Wu (1999) employ the individual unit root process, the common unit root process is adopted by Levin, Lin and Chu (2002) while assuming asymptotic normality in computing the probability values. The tests were computed in levels, then for the first difference and the result are supplied in Table 5 with all the variables stationary at first difference i.e I (1).

Table 5: Panel Unit Root Test

Variable	LLC		IPS		Fisher-ADF	
	c	t	c	t	c	t
rec	0.866	-2.091	1.868	0.801	9.038	9.086
log*drb*	-0.059	-2.513*	0.884	-0.756	8.828	15.748
logCO_2	0.905	-0.301	3.212	1.911	4.222	9.742
ln*gdp*	-6.533*	-7.965	-3.081*	-1.970**	74.429*	43.352
Δ*rec*	-7.794*	-6.805*	-5.620*	-4.051*	55.511*	41.185*
Δlog*drb*	-3.363*	-2.999**	-2.333*	-1.001	27.051**	18.413
ΔlogCO_2	-2.402*	-3.738**	-2.200**	-3.211*	28.274**	35.404*
Δln*gdp*	-15.801*	-11.656***	-9.196*	-7.711	326.618*	97.136*

Note: LLC, IPS and Fisher-ADF are the Levin, Lin and Chu (2002); Im, Pesaran and Shin (2003); Fisher-ADF by Maddala & Wu (1999) panel unit root tests. For the unit root estimate, c and t are intercept and trend respectively. The *, ** and *** represent significant levels 1%, 5% and 10%.

3.3.2 Dynamic Pooled Mean Group Test

The Time period (T) is clearly greater than the number of cross-section (N), thus a Pooled Mean Group (PMG) of dynamic heterogeneous panel is preferably employed (Pesaran, Shin & Smith, 1999). As a preferred and more robust model to Generalized Method Moments (GMM) and Mean Group (MG) in this investigation, the Pooled Mean Group (PMG) estimation adopts the cointegration form of the ordinary ARDL model as indicated by Pesaran, Shin and Smith (1999). When the equation (2) is estimated according to the aforesaid (PMG) error correction model, the represented expression is simplified as:

$$\Delta y_{i,t} = \phi_i EC_{i,t-1} + \sum_{j=0}^{q-1} \beta_{i,t} \Delta X_{i,t-j} + \sum_{j=1}^{p-1} \lambda_{i,j} \Delta y_{i,t-j} + \varepsilon_{i.t} \tag{3}$$

where the error correction $EC_{i,t} = y_{i,t} - X_{i,t}\theta$ is the deviation from the long-run equilibrium, ϕ is the adjustment coefficients (i.e the short-run error correction term that measures the speed of adjustment toward the long-run) and θ is vector of the long-run coefficients such that $X = f\,(\log CO_2, \log drb, \log gdp)$ in the models. Also, β is a vector of short-run coefficients, $\varepsilon_{i,t}$ is the error term associated with different cross section variance that results from country-specific effects. The estimation from the expression (3) is presented in Table 6.

Table 6: Pooled Mean Group Test with ARDL Specifications

	log*gdp*	log*drb*	logCO_2	*Adjustment parameter*
Long-run	0.0796(0.000)*	-375.092(0.000)*	-201.853(0.000)*	-0.458(0.016)**
Short-run of cross-sections				
1	0.002(0.513)	57.845(0.995)	-1503.439(0.998)	-0.044(0.018) **
2	-0.089(0.000)*	629.282(997)	2759.466(0.937)	-1.353(0.000)*
3	-0.117(0.000)*	473.041(0.993)	-555.820(0.997)	-0.707(0.000)*
4	-0.014(0.000)*	-48.860(0.996)	-1305.272(0.998)	-0.877(0.050) ***
5	0.052(0.002)*	107.655(0.989)	-1571.723(0.189)	-0.1676(0.004)*
6	0.052(0.000)*	48.079(0.995)	-19.535(0.990)	-0.130(0.079) ***
7	0.222(0.000)*	-74.701(0.118)	1961.472(0.918)*	-0.715(0.003)*

Diagnostic test (Cross-sectional Dependence Test, Null hypothesis: Cross Sectional Independence)

Person CD Normal: t-statistics = 0.982, Probability value = 0.326
Breusch-Pagan Chi-square: t-statistics = 27.777, Probability value = 0.476

D.F. = 28

Note: *, ** and *** are statistical significance at 1%, 5% and 10% respectively. D.F. is the Degree of freedom. The estimated model is ARDL (2, 1, 1,1). For the short-run cross sections, Spain =1, France = 2, Slovenia = 3, Greece = 4, Turkey = 5, Lebanon = 6 and Israel = 7.

3.4 Empirical Results and Discussion

From the preliminary estimation, statistical evidence shows correlation between the investigated variable as indicated in Table C of the appendix. Moreover, for the stationarity investigation, panel unit root tests were employed using the Levin, Lin and Chu (2002), Im, Pesaran and Shin (2003) and the Fisher-ADF by Maddala and Wu (1999) approaches. With the results of the panel unit root tests presented in Table 5 (lower part), which provides evidence of a mixed order stationarity, the appropriate estimation model – the Autoregressive Distributed Lag (ARDL) is employed. Hence, Table 6 presents the results of the Pooled Mean Group (PMG) of the study's dynamic heterogeneous panel. For the panel estimate as shown in Table 6, all the explanatory variables are observed to be statistically significant in long-run and with adjustment parameter of about 45.8%. While the long-run impacts of *gdp* on *rec* is significant and positive which agrees with the results from previous section, the impact of CO_2 and *drb* on *rec* (renewable energy consumption) is significant and are both negative. This implies that a 1% increase in the numbers of dwellings, building and residential constructions (*drb*) and *cem* will cause a significant decrease of about 3.75 kilotons and 2.01 kilotons in (*rec*) renewable energy consumption respectively. Also, in the long-run, a 1% increase in the real *gdp* will cause a significant increase of about 0.0079.6 kilotons in (*rec*) renewable energy consumption.

Although, Sørensen (2008) fell short of a wider coverage of the study of an interaction between renewable energy and construction demand, however, the investigation is quite similar to the current study. In this case, and in the long-run, a 1% increase in carbon dioxide (CO_2) emissions will reduce the renewable energy consumption (*rec*) in the total energy mix by about 2.01 kilotons. On the other hand, the short-run and the cross-sections impact of *gdp* on *rec* is significant in all the panel countries except in Spain. Additionally, the cross section short-run impact exhibited by *gdp* on *rec* is negative for France, Slovenia and Greece while the impact is positive for Turkey, Lebanon, and Israel. Interestingly, the RES information in Table 4 indicates that Spain, Greece and Turkey are among the countries with the highest renewable shares in Total Primary of Energy Supply (TPES). It could then be argued that the renewable energy source in these countries are land (arable land) intensive.

3.5 The Diagnostic Test

Given the possibility of the problem of contemporaneous correlation or cross-sectional correlation resulting from cross-section dependence (CSD) in the panel estimate, our study performed a cross-section dependence test. Foremost, employing the Person CD Normal and the Breusch-Pagan Chi-square test (it reports a desirable cross-section independence as a null hypothesis), the observed result in the lower section of Table 6 of the appendix shows no cross-section dependence in the panel countries. Hence, in the current study, there is no concern of estimation bias resulting from long-range and the spatial dependency (as observed by Moscone & Tosetti, 2010) and the use of Marco panels with long time-series and Micro panel with few time-series (as observed by Baltagi, 2008). This is in addition to the pairwise Granger causality estimate of Table 7 that further explains the relationship between the historical relationships between the variables. As observed in the Table 7, the previous information (history) of CO_2 is significant in predicting the present and future information of *rec*, and importantly without a feedback. Moreover, the result presents a feedback Granger causality between CO_2 and *drb*. Informatively, looking at the correlation estimates of the variables as presented in Table (B) of the appendix, the result potentially provides a foundational insight to the investigation.

Table 7: Panel Granger Causality (Pairwise estimate) Results

Null hypothesis	w-stat	*P*-value	Direction
$rec \rightarrow \log CO_2$	0.558	0,574	
$\log CO_2 \rightarrow rec$	3.558	0.022**	Uni-directional
$rec \rightarrow \log drb$	0.660	0.519	
$\log drb \rightarrow rec$	4.374	0.015	
$\log CO_2 \rightarrow \log drb$	3.958	0.022**	
$\log drb \rightarrow \log CO_2$	11.393	4.E-05*	Bi-directional
$\log co_2 \rightarrow \log gdp$	0.050	0.958	
$\log gdp \rightarrow \log CO_2$	8.832	0.000*	Uni-directional
$\log gdp \rightarrow rec$	8.768	0.000*	
$rec \rightarrow \log gdp$	1.285	0.281	Uni-directional

Note: ** and * are statistical significance level at 5% and 1% respectively.

3.6 Conclusion Remarks and Policy Implications

In this study, an investigation that examined the long-run and short-run dynamic heterogeneous nexus of renewable energy consumption with carbon emission (CO_2), housing construction policy (*drb*), and the real gross domestic product (*gdp*) is considered. The impacts of the main explanatory variables of the investigation (carbon dioxide, real gdp, and the housing dwellings and residential constructions) were examined in a panel of seven CMC over the period 1999-2015. With the PMG approach employed, the model presents an equilibrium adjustment parameter of approximately 45.8%. The study is limited to seven CMC (Spain, France, Slovenia, Greece, Turkey, Lebanon and Israel) as indicated earlier due to lack of data availability. One important observation from this is that the limitation of renewable energy and the housing allocation policy data is prominent for most of the North African countries of the CMC. It then translates that housing allocation policy and consumption of the RES among the North African countries of the CMC is lower compared to the Middle East and European countries of the CMC. But, our observation from Table 4 also indicates that the generation of RES decreases along the coastline of the Mediterranean. The order is specifically from the European coastline to the Middle East and lowest in the North African region of the coast. However, evidence from the study indicates that CMC region is potentially important for RES, considering its natural geography and environmental remoteness. Obviously, this assertion is robust given that the total resource rents posit similar long-run result as modelling with *res*.

By implication, the inference from the interaction between housing allocation and renewable energy in the panel countries examined suggests an interesting challenge to policymakers. In recent times, especially since early 2000, an appreciable percent of RES (millions tonnes of oil equivalent, MTOE) is increasingly being utilized in the countries examined. Evidently from the Tabel 4, biofuels and waste is observed to have the highest component of the RES in all the countries examined. Also, in the countries examined, tens or hundreds(s) of thousand(s) of dwellings, building and residential structures are allocated for construction annually as a policy. Giving a normal intuition, more dwellings and building allocation should translate to increase in REC (the renewable share in total energy per kilotons). Expectedly, the long-run estimate of the panel suggests a similar outlook; it posits a positive long-run relationship between the peculiar housing policy and RES. The implication of this is that continuous expansion and housing construction in the panel of countries in a long-run would potentially increase the demand for renewable energy, thus increasing the REC. However, in Spain, Greece, and Turkey, the construction and allocation of buildings is observed to have negative short-run impact on REC. The result justifies the empirical that RES in this panel of countries is largely developed domestically in the panel countries and mostly depend on the resources from the environment (these are land, agricultural source, water, and others) (see Alola, A. & Alola, U., 2018). Also, for the positive short-run and cross-section relationship (see France, Slovenia, Lebanon and Israel in Table 6), it could be adjudged that the growth rate of RES as a share of TPES is not land intensive (land being the main component of housing). As such, the source of RE could rather be from wind and solar powers at least for a short period of time (US EIA, 2017). As also noted in Sadorsky (2009a), the implication of having an increased CO_2 emission causing higher REC is that energy stakeholders will be more concerned about the issue of global warming. Therefore, the increased awareness of climate change will expectedly be geared toward discouraging the fossil fuel consumption and thus increasing the renewable shares in total energy consumption. It implies that regular oil investors are likely to shift their investments to renewable energy and thereby causing expansion and profitability of the renewable energy market.

A further direction for prospective investigations in the field of renewable energy especially in the CMC could be to look at other environmental components of the Mediterranean Sea (salinity, pollution, etc.) using an empirical analysis. The peculiarity of the region (CMC) in the study of renewable energy is strongly associated with the geographical and resource spread along the coast. As such, incorporating all or at least sizeable number of countries in any further investigation is desirable. Lastly, further study could consider extending the research using household data of the CMC, because it could provide a more comprehensive approach to understanding the dynamics of RE in the region.

Chapter 4

RENEWABLE ENERGY AND AGRICULTURAL PRICES

4.1 Introduction

Studies have shown that alternate source of energy is a key determinant of environmental and sustainable development. In sustaining a desirable status of socio-economic development which has continued to justify the search for alternative sources of energy, there has been an increased pressure for renewable energy. It is because energy from a RES is capable of supplying and guaranteeing pollution-free, cost-effective, non-depleting energy source. Although fossil fuels are currently reported to account for 80% of the global total primary energy sources/consumed (TPES), biofuels, hydrogen, natural gas and synthesis gas are the four supposedly important source of energy in the nearest future (Kikas et al. 2016). Importantly, bioenergy, geothermal, hydropower, ocean, solar and wind are the main utilized sources of renewable energy i.e. a regenerated source of energy unlike the fossil fuels (Energy International Agency, IEA 2018). Detailing further, the IEA put the current statistics of the aforementioned RES as: bioenergy and biofuels accounts for about 9% of TPES, hydropower accounts for about 17% of TPES (largest source of renewable electricity globally), ocean energy accounts for smallest TPES, solar energy accounts for over 1% of global power output, wind energy account for about 4% of global electricity generation and geothermal energy provides about 90 Terawatts per hour (TWh) globally. Among the above RES, bioenergy is mostly utilized across the globe.

Obviously, the motive would be the utilization of natural resources, environmental-friendliness, biodegradability and the constituents of the exhaust gases. For instance, biomass (a bioenergy) which is primarily the first energy source harnessed by a human, has remained a highly sort-after energy source by about half of the world population. (Qiao et al. 2016). Also, biodiesel which could be proportionately mixed with hydrocarbon fuels is biodegradable and less pollutant. It accounts for reason agricultural crops and residues are important in the production of renewable energy. Some of the agricultural residues utilized for renewable energy include residues from arable plant/crops and animals. As several studies continued to add to extant literature within the framework of renewable energy, the important of RES to mankind and development across the sector of the economy remains crucial. The work of Apergis and Payne (2010) is among the extant literature that studied renewable energy consumption in relation to economic growth. In the context of renewable energy, studies have continued to emerge in relation to broad range of factors such as; income growth, health-related factors, advanced technology, resource and environmental depletion, sectoral development, and financial development (Jennings, 2009; Mumtaz et al. 2014; Adämmer & Bohl, 2015; Wakil, Kalam, Masjuki & Rizwanul Fattah, 2016; Rezec & Scholtens, 2017; Asonja, Desnica & Radovanovic, 2017; Umekwe & Baek, 2017; Alola, A. & Alola, U., 2018).

In this case, the study of the response of renewable energy viz-a-viz renewable energy equity (REE) to the prices of agricultural prices in the United States is carefully examined. The study which has considered the daily datasets spanning 20 January 2012 to 2nd August 2018 is conducted with a Markov Switching (MS) regression model. The motivation for exploring the study of renewable energy is in folds. Firstly, agriculture imperatively produces a large number of biofuels. Among these are the agricultural residues, these include cornstalks, straws, corn cob and tree/plant/fruit orchards pruning residues. Secondly, the US which is investigated in the current study has continued to present interesting energy-mix dynamics and ranked among the highest energy consumption globally. The current government policy regarding climate change, which is noticeable in the country's recent withdrawal from the 2015 Paris climate agreement, suggests an interesting perspective. Until now, the country's primary energy sources are the fossil fuels, nuclear energy and the RES. But the proportion of these energy sources utilized in the United States is sector-specific. For instance, biofuels and waste such as from agriculture account for about 4.2% of TPES of electricity generation. Lastly, although the United State economy is not agriculturally-driven primarily, the country produces vast agricultural products/wastes (Adämmer & Bohl, 2015; Umekwe & Baek, 2017). As such, the dilemma of meeting the country's energy and especially the renewable energy demand amid food security challenge presents an interesting study.

In the light of the motivation highlights above, the current study combined, examined, and further advanced the key knowledge in the study of Adämmer and Bohl (2015) and Rezec and Scholtens (2017). While Adämmer and Bohl (2015) pointed out the importance of Corn, Soybeans and Wheat prices to crude oil prices and real exchange rates of the United States, Rezec and Scholtens (2017) observed the significance of renewable energy equity indices in financing energy transformation. Hence, in novelty, our study hypothesize the likelihood of regime inference(s) that arises from the dynamics of the renewable energy equity as caused by daily agricultural prices (see visual evidence in Figure 4). Like Adämmer and Bohl (2015), the agricultural prices employed are the prices of corn, soybeans and wheat because they are the three largest crop production in the United States.

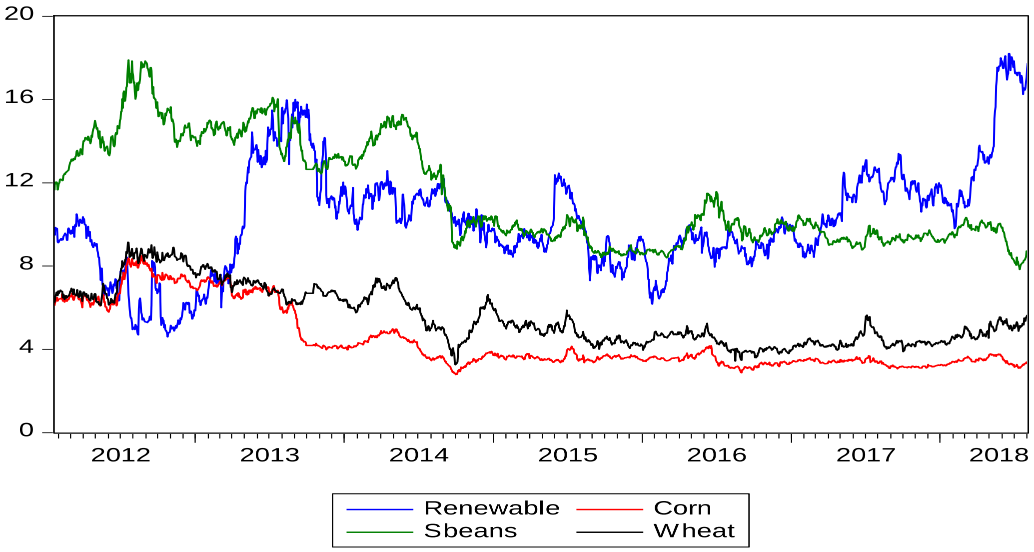

Figure 4: The Relational Behaviour of the Variables.

The rest of the sections present an overview of renewable energy and selected agricultural crops produced in the United States, empirical methodologies, empirical findings, the concluding remarks.

4.2 A Brief Overview of US the RES

In recent times, greater importance has consistently been attached to the traditional sources of energy as evident in the US Federal policies toward attaining cleaner energy policy. In the United States, due to the persistent surge in the growth of renewable energy, the TPES from the renewables by 2040 is expected to be about 12.1% with electricity generation projected at about 16% (International Renewable Energy Agency, 2018). While hydropower production suffered a decline of about 2.6% of TPES from 2003 to 2013, energy generation from solar power was observed to double during the same period. Biofuels and waste were noted to have expanded by about 30.6% of TPES, while 6.2% of TPES was added by geothermal. But globally, the United States is the world leader and highest installer of geothermal energy capacity. In 2014, the United States accounts for 58 hydroelectric power plants which are capable of powering 3.5 million homes and generating one billion USD in revenues. While the goal to double the country ’s renewable electricity from wind power, solar power and geothermal resources were achieved in 2013 (from 2008 baseline), the US has again set a new target to double the same energy source by 2020 using the baseline of 2012.

The importance of biofuel in the energy structure of the US accounts for the active research and development collaborations of government agencies like the US Department of Agriculture (USDA), Department of Environment. The policies and measures of the government on renewable energy like the production and investment tax credit and renewable portfolio standards have continued to constitute renewable energy market and equity guide. Through the enacted tax reforms like the corporate tax reforms which have subsequently reduced the corporate income tax, the tax liabilities of the energy companies has subsequently declined. As such, institutional energy investors often benchmark their financial performance using renewable energy indices (i.e. baskets of investments/projects) as an instrument for measuring potential energy project debt and investable assets (Rezec & Scholtens, 2017).

4.3 RE from Agricultural Source

On one hand, agricultural crops or plants and wastes have consistently been utilized as sources of renewable energy fuels. The quality of RE from agricultural would largely depend on both the agricultural product and the method of production. For instance, transesterification methods which could be acid, base lipase-catalyzed are common methods of producing biodiesels (Wakil, 2016). Also, the yield of bioethanol and biogas is reportedly dependent on the level of cellulose and lignin in the biomass respectively (Kikas et al. 2016). And, on the other hand, the increase in agricultural prices which are largely responsible for the hike in food prices have a huge impact on inflation, and the living standard of the people. Notably, Reboredo (2012) linked the association between energy and agricultural prices to the fact that energy is utilized in agricultural production, even as soybean and corn remain heavily demanded. Similarly, the prices of corn, soybean and wheat were considered while investigating the potential bubbles in US agricultural prices by Adämmer and Bohl (2015). Also, when agricultural commodity prices were investigated in relation to world oil prices by Nazlioglu (2011), strong cointegration evidence was statistically significant.

4.4 Data and Estimation Methodology

Based on one sector (agricultural) analysis as obtainable in Adämmer and Bohl (2015), data for corn, soybeans (sbean) and wheat prices with other independent variables in the study were collected from the Federal Reserve Bank of St. Louis (FRED) where the agricultural prices of the three commodities are the non-seasonally adjusted Producer Price Index (index 1982 = 100). The trade-weighted US dollar index[8] (tindex) is employed to control for the unobserved variable (i.e global financial market, the United States dollar exchange rate, e.t.c.). Also, the dependent variable employed is the renewable energy equity index[9] (requity). The aforementioned datasets spans from 20/01/2012 to 02/08/2018, also the correlation information and descriptive statistics could not be provided because of space constraint.

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[8] The Trade weighted US dollar is the weighted index is the average of the foreign exchange value of the U.S dollar against major trade partner currencies and obtained from the FRED (Federal Reserve Bank of ST.LOUIS.

[9] Renewable energy equity is the aggregate equities of the renewable energy market from the Thomson Reuters DataStream.

4.4.1 Model Representation and Estimation

Prior to applying the Markov Switching approach, the applied stationarity tests (Kwiatkowski, Phillips, Schmidt & Shin, 1992), the KPSS revealed that the variables are stationary at *I*(*1*) and corroborated by Zivot and Andrews (1992) unit root for single breaks as observed in Table 8. In addition, the results of the Zivot and Andrews (1992) unit root for single breaks further provides information of potential breaks which can be corroborated by significant event(s) during the observed year(s). From the literature, we employ a multivariate approach model such that the ordinary least squares (OLS) regression is a model as

$$requity_{i,t} = \beta_{o,i} + \beta_{1,i}Corn_t + \beta_{2,i}Sbean_t + \beta_{3,i}Wheat_t + \beta_{4,i}Tindex_t + \varepsilon_{i,t} \tag{1a}$$

where *t* is the daily periods, ε_t is the error term, and slope parameter to be estimated ($\hat{\beta}$) for each corresponding independent variable. Also, from (1a), $Corn_t$, $Sbean_t$, $Wheat_t$, and $Tindex_t$ are the corn price shocks, soybeans price shock, wheat price shock, and the trade-weighted shock. When the switching intercepts are incorporated, the Markov switching dynamic regression of Hamilton (1989) as simplified by Uddin et al (2018) and Reboredo (2010) is presented as follows as:

$$requity_{i,t} = \beta_{o,\mathrm{i},\mathrm{rt}} + \beta_{1,i,rt}Corn_t + \beta_{2,i,rt}Sbean_t + \beta_{3,\mathrm{i},\mathrm{rt}}Wheat_t + \beta_{4,i,rt}Tindex_t + \varepsilon_{i,t} \tag{1b}$$

Given that for all $\varepsilon_t \sim N(0,\sigma^2_{st})$, the switching intercept and variance of error are respectively $\beta_{0,i,rt}$ and σ^2_{st}. Also, the effect of the prices of $Corn_t$, $Ai = \phi_1 Ai{-}1 + \phi_2 Ai{-}2 + \cdots + \phi_p Ai{-}p$ and $Wheat_t$ on the equity of *renewable energy* ($requity_{i,t}$) in different regimes are respectively $\beta_{1,i,rt}$, $\beta_{2,i,rt}$, $\beta_{3,i,rt}$, $\beta_{4,i,rt}$ where r_t (regime dependent) is a discrete regime variable. A latent unobserved state variable, *i* takes on values 1 and 2 such that state 1 and state 2 (state of the economy) are respectively known as the *high* and *low* regimes as indicated in Table 9.

Table 8: The KPSS stationarity Test and Zivot-Andrew (ZA) Unit Root Test under Single Structural Break

	Level		Δ		
Variables	*with intercept*	*intercept and trend*	*with intercept*	*intercept and trend*	*Conclusion*
Requity	0.8685*	0.3614*	0.1392	0.0619	*unit root present at level and stationary at Δ*
Corn	3.7955*	0.8443*	0.0939	0.0757	
Sbean	3.9732*	0.5429*	0.0975	0.0832	
Wheat	3.9617*	0.5844*	0.0849	0.0724	
lnTindex	4.7148*	0.6350*	0.0686	0.0698	

		Level			Δ	
Zivot Andrew	ZA_I	ZA_T	ZA_{IB}	ZA_I	ZA_T	ZA_B
Requity	-2.96	-2.76	-3.14	-41.69*	-41.59*	-41.79*
	3/9/2014	*9/8/2017*	*7/7/2015*	*4/9/2013*	*8/8/2017*	*9/7/2013*
Corn	-5.83*	-3.83	-5.65	-18.03*	-18.00*	-18.26*
	23/7/2013	*10/7/2014*	*12/7/2013*	*21/3/2013*	*25/7/2013*	*1/10/2013*
Sbean	-5.34*	-4.13	-5.32**	-41.19*	-41.21*	-41.30*
	30/6/2014	*13/8/2015*	*30/6/2014*	*6/10/2014*	*13/8/2014*	*29/9/2014*
Wheat	-4.28	-4.14	-4.42	-18.67*	-18.66*	-18.80*
	9/5/2014	*12/8/2016*	*9/5/2014*	*2/10/2014*	*25/2/2013*	*2/10/2014*
lnTrade	-3.64	-2.53	-3.71	-17.06*	-16.93*	-17.21*
	30/10/2014	*9/11/2015*	*19/6/2015*	*18/12/2015*	*3/11/2014*	*12/1/2017*

Note: Level and Δ respectively indicates estimates at the level and first difference. Automatic lag selection by SIC (maxlag=24) for unit root test and maxlag=4 for ZA). ZA is the Zivot & Andrews (1992) for a unit root structural break test where ZA_I, ZA_T & ZA_B are an intercept, trend and intercept with the trend of ZA estimates.

Table 9: Constant Markov Switching Model

Parameters	Regime 1	Regime 2		
$\beta_{0,i}$	40.29182*	-165.9442*	P11	ERD
$\beta_{1,i}$	-1.85848*	-1.718225*	0.995856	[241.3131] ^{erd}
$\beta_{2,i}$	0.548827*	0.88260*		
$\beta_{3,i}$	0.157376*	3.124318*		
$\beta_{4,i}$	-6.43260*	33.74707*	P22	ERD
σ_i	-0.22631*	0.442858*	0.994191	[172.1536] ^{erd}
log-likelihood	-0.26163*	0.65460*		
Residuals (Diagnostic test)				
	Skewness	0.410327		
	Kurtosis	4.382174		

Note: Regime 1 implies i=1 and regime 2 implies i=2. Also, λi, χi, and ϕi are respectively coefficient of the alternative effect of prices of Corn, Sbeans (Soya beans) and Wheat on the equity of renewable energy. * implies the statistical significance at 1% level and erd the regime expected duration.

Further to the original Hamilton specification of a constant Markov switching model[10], a Markov switching specification is employed. In this case, a stochastic regime switching process that follows homogeneous, ergodic, and first order Markov chain with constant transition probabilities and two (2) regime numbers is assumed. As such, and in the regression, the dynamic transition probability of the matrix is given as:

$$P(t) = \begin{bmatrix} P_{11t} & 1 - P_{22t} \\ 1 - P_{11t} & P_{22t} \end{bmatrix} \quad (2)$$

The probability of transmission from regime 1 at time period t to regime 2 at time period *t + 1* depends entirely on the regime at time period *t*. And, given the dynamics

---

[10] Detail of the constant Markov switching model is not expressed here because of space constrain and can be followed up in Hamilton (1989).

of both the renewable energy equity in respect to the prices of corn (*p*), soybean (*q*), wheat (*r*) and unobservable factor (*tindex*) is a time-varying possibility of regime switching which is associated with dynamic transition probabilities;

$$P11_t = \frac{\exp\left\{\gamma_1 + x_1 p_{t-1}^{Corn} + u_2 q_{t-1}^{Sbean} + v_1 r_{t-1}^{Wheat} + w_1 s_{t-1}^{Tindex}\right.}{1+\exp\left\{\gamma_1 + x_1 p_{t-1}^{Corn} + u_2 q_{t-1}^{Sbean} + v_1 r_{t-1}^{Wheat} + w_1 s_{t-1}^{Tindex}\right.} \text{ and}$$

$$P22_t = \frac{\exp\left\{\gamma_2 + x_2 p_{t-1}^{Corn} + u_2 q_{t-1}^{Sbean} + v_2 r_{t-1}^{Wheat} + w_2 s_{t-1}^{Tindex}\right.}{1+\exp\left\{\gamma_2 + x_2 p_{t-1}^{Corn} + u_2 q_{t-1}^{Sbean} + v_2 r_{t-1}^{Wheat} + w_2 s_{t-1}^{Tindex}\right.} \qquad (3)$$

From the equation 3 above, the significant value of the parameters χ_1 and χ_2 , u_1 and u_2, v_1 and v_2 in addition to w_1 and w_2 respectively determines the impact of corn price, soybean price, wheat price and the control variable on the regime transition probabilities. Also, γ_1 and γ_2 are responsible to give the regime transition probabilities. Given an increase in the independent variables, renewable energy equities are likely to remain in regime 1 as the coefficient of the independent variable(s) is/are positive(s) and vice versa in the case of regime 2. Moreover, information from the filtered regime probabilities (See Figure 5), the diagnostic residual test (see Figure 6) and the forecast estimate (not provided because of space constraint are significantly robust.

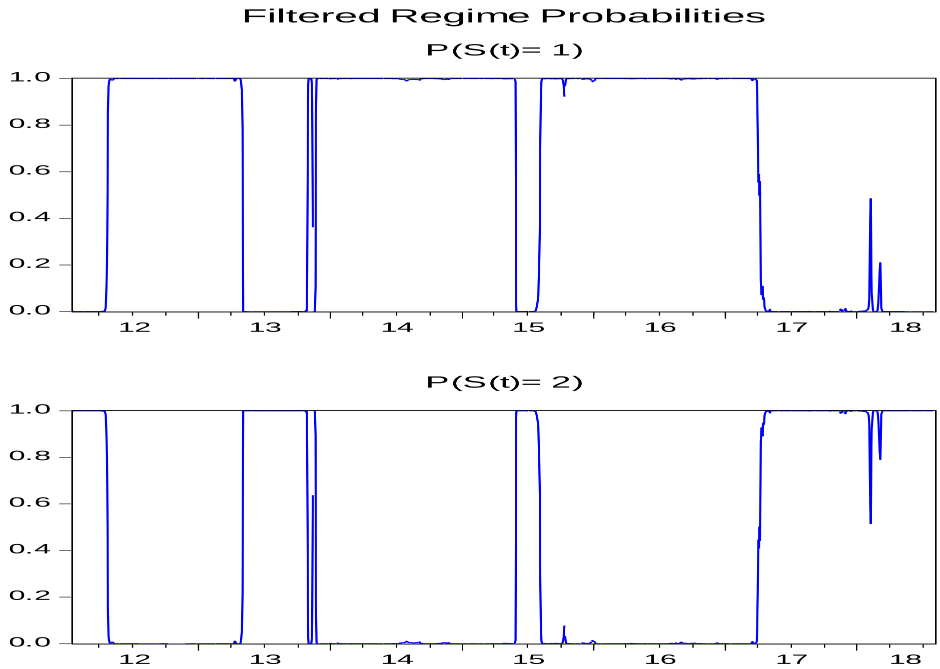
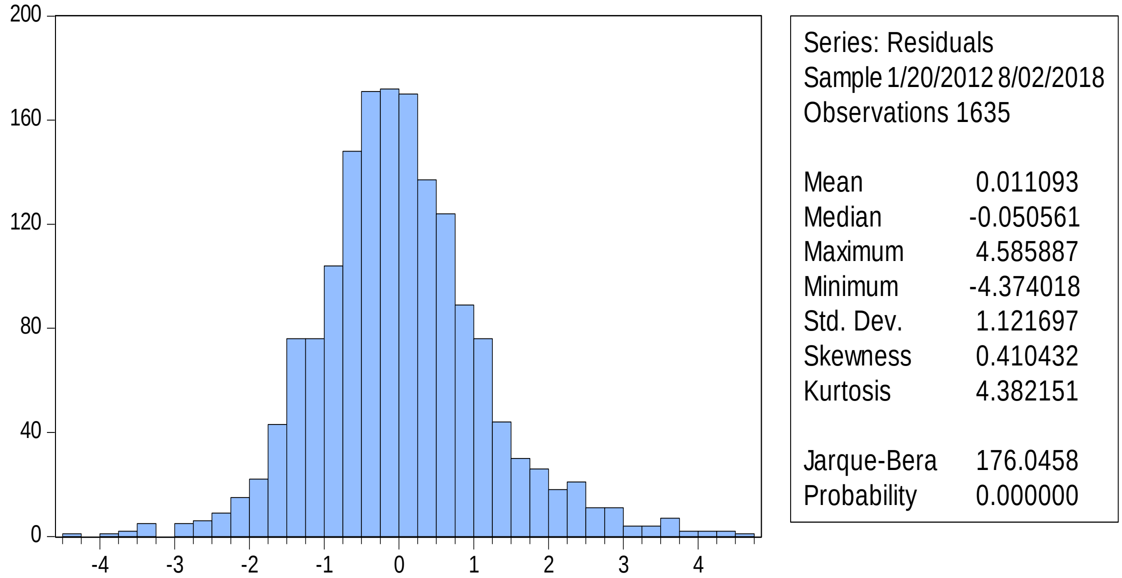


Figure 5: The Filter Regime Probabilities of the Regimes.



```
Series: Residuals
Sample 1/20/2012 8/02/2018
Observations 1635

Mean          0.011093
Median       -0.050561
Maximum       4.585887
Minimum      -4.374018
Std. Dev.     1.121697
Skewness      0.410432
Kurtosis      4.382151

Jarque-Bera   176.0458
Probability   0.000000
```

Figure 6: A Residual Diagnostic Estimate of the Model.

4.5 Empirical Findings

The series time series stationarity KPSS test indicates that the series is *I(1)* which was corroborated by the ZA (1992) unit root single structural break test as shown in Table 8. Further, the appropriateness of the Markov switching model is shown in the significant evidence of the switching parameters 40.29182 and -165.9442 (of high and low) indicated in Table 9. Also, rejecting the null hypothesis of independent state variables as shown in the significance of the state variables support the employed Markov switching model. The log-likelihood of the regimes are also significant (-0.26163 and 0.65460). Importantly, the Markov switching model with a constant parameter for the United States shows that the equity market of renewable energy responds differently with a significantly varying degree in each of the regimes (i.e. High regime = regime 1 and low regime = regime 2). Although the impact of corn prices is significantly negative on RE equities in both regimes, such impact is lower in regime 1. Similarly, the prices of soybeans and wheat are significantly positive in the regimes, these impacts are also lower in regime 1. But the trade-weighted in US dollars (control variable) is found to significantly impact negatively and positively in regimes 1 and 2 respectively. Furthermore, with a 99.59% probability of ensuring a persistent regime 1 (i.e. 0.41% of switching to regime 2), and a 99.42% of a persistent regime 2 (i.e. 0.58% of switching to regime 1), the regimes are found to be persistent and remain so for 241 days and 172 days respectively. In addition to the robustness evidence is the desirable result of the residual diagnostic (i.e skewness = 0.41 and kurtosis = 4.38) of Figure 6.

4.6 Conclusions

In the United States, energy from renewables was found to have grown by about 9.1% from 2008 to 2012 and subsequently experienced a robust growth of about

15% from 2012 to 2017 (International Renewable Energy Agency, 2018). Then, it is justifiable to study the regime dynamics of equities of this source of energy in relation to agricultural commodity prices vis-à-vis corn, soybean and wheat by employing the Markov switching model. Our study found a significantly negative impact of the corn price on the renewable energy equity in both regimes. Such impact is positive for soybean and wheat during the regime periods, this coincides with the result of Nazlioglu (2011). Expectedly, soybean has the highest share of RE source and the highest share of harvest export (Adämmer & Bohl, 2015). The unexpected result for corn could be associated with recent findings that opined the use of corn for food rather than energy because of inherent environmental cost.

The policy direction of the government and stakeholders should be geared toward a sustainable energy and agricultural framework. Considering the RE market and food security, an efficient food subsidy program, more agricultural investment should be further encouraged. And further study could focus on the response of different RE equity indices as regard to agricultural prices.

Chapter 5

COMMODITIES SPILLOVER: NEW INSIGHTS FROM THE HOUSING, ENERGY AND AGRICULTURAL MARKETS IN THE UNITED STATES

5.1 Introduction

Generally, connectedness is mainly associated with return market and credit risk, counter-party and gridlock risk, systemic risk, and the underpinning of fundamental microeconomic risks (Diebold & Yılmaz, 2014). The fact that shocks are transmitted around the global trading system has continued to be an interesting phenomenon. In reality, understanding this trend and deducing useful financial and economic inference, especially of the market correlation and spillovers is an associated bottleneck to researchers and investors. This is because the characteristic movements across markets are often associated with intra-national (domestic) or international market linkages and connectedness. The transmission of financial market volatility or risk importantly informs an effective security pricing, sustainable asset allocation, and at establishing the limits of diversification (Steeley, 2006). An illustration of the international connectedness of the financial market was globally experienced during the ‘Great Crisis’ of 2007-2011. This global financial crisis (GFC) which forcefully began in the United States’ (US) sub-prime mortgage market (lasting about a year and half in the country at different stages) before unleashing strange distress in the financial and government institutions of the European Union (EU) countries between 2010 to 2011 (Diebold & Yilmaz, 2015a).

Giving the idea of the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) (Robinson et al., 2015) as expressed in the previous chapter (1), investigating the inter-market dynamics posits economic implications. Importantly studying the connectedness of the major US financial institutions' stock return volatilities is as important as understanding the risks connectedness of the country's major markets, especially the risks of its macroeconomic markets. Being the largest Gross Domestic Product (GDP) measured at Purchasing Power Parity (PPP) conversion rates for more than a century, the U.S economy is currently the second largest behind China in the last four years (CIA, 2018). That is the reason the country's macroeconomic sectors have continued to largely determine the dynamics of the global markets. For instance, the country's economy is energy-intensive, so the dynamics of the US's energy market would potentially affects the global oil price. Despite the global campaign for energy transition amidst increasing concern of climate change challenges, energy consumption in the US has remained high but with a declining rate of carbon emissions (British Petroleum, 2018). The demands for renewable energy sources (RES) in the US in this circumstance and the continued exportation of agricultural commodities (especially grains: Soybeans, wheat, and corn), also suggests the importance of the country's agricultural sector to its economy. Significantly, a similar position of importance is held for the US housing and real estate market, considering the association of the housing and real estate (mortgage) crisis with the GFC.

Considering the importance associated with the aforementioned sectorial markets of the United States economy, the current study investigates the (dynamic) returns and volatility spillovers of these US macroeconomic market (housing, energy, and agricultural commodities) components. For instance, the US's majorly cultivated agricultural crops or grains that were largely exported in 2017 are: wheat (worth $ 6.1 billion), corn (worth $ 9.1 billion), and soybeans (worth $ 216 billion) (USDA, 2018). The aforementioned agricultural commodities are also known (RES). Hence, investigating the connectedness of the housing market, energy market (of fossil fuel and RES), and the agricultural commodity market shocks will potentially contribute a degree of novelty to the body of existing literature. And, to author's best knowledge, the described novel objective that is originally considered here is of unique note for certain reasons. First, in lieu of conventional methods of examining correlations of the dynamic markets (Kal, Arslaner & Arslaner, 2015; Balcilar, Demirer & Hammoudeh, 2013; Balcilar, Hammoudeh & Asaba, 2015; Basher & Sadorsky, 2016), the study employs the Diebold and Yilmaz (2012) for the measurement of specific spillover indexes that comprises of the gross and net spillover indexes, and directional interdependency (spillover) index. In addition to the spillover index computations, it compliment with the more efficient rolling-window analyses. Secondly, the study adopts RES component (renewable energy equity), oil prices of both West Texas Intermediate (WTI) and Brent crude, and the commodity prices of Soybeans, Corn and wheat. As such, the investigation additionally provides the underpinning of the component-based shocks. Lastly, this investigation of microeconomic markets connectedness via returns and volatility spillovers also suggests potential market (s) useful for hedging and diversification opportunities in the US.

The rest of the sections are in part. The next section 2 contains a synopsis of the literature review. Data and methodology are presented in section 3 while the results are discussed in section 4. Section 5 offers concluding remarks that include policy implication of the study and proposal for future study.

5.2 Related Literature

In extant studies, the categorization of the literature includes the studies that address both identical financial assets and including inter-assets spillovers. For instance, there are studies specifically measuring the connectedness of financial markets (Diebold & Yilmaz, 2014, 2015a), stock markets (Baruník, Kočenda & Vácha, 2016), and bond market (Fernández-Rodríguez, Gómez-Puig & Sosvilla-Rivero, 2015; Ahmad, Mishra & Daly, 2018). Also, there are existing literature dealing with the spillovers of bond and equity or financial and bond markets (Salisu, Oyewole & Fasanya, 2018; Ahmad, Mishra & Daly, 2018). In addition to financial and macroeconomic spillovers (Diebold & Yilmaz, 2015b; Barunik & Krehlik, 2016), studies have demonstrated macroeconomic connectedness with other market indicators. The macroeconomic markets employed in the study of Diebold and Yilmaz (2015b) are the component assets of stock, bond, foreign exchange, and commodity with financial institutions. In the study, which adopts US and foreign countries financial institutions, the stock markets are noted for spreading the volatility shocks from the US to other countries. Also, there is gradual increase over time of the return spillover across stock markets. But during major crisis events, significant jumps are main determinant of the measures of volatility spillovers. Massacci (2016) similarly demonstrated the spillover of the stock returns, macroeconomy and global markets. The study measures tail connectedness by using the daily returns from the U.S size-sorted decile stock portfolios of large and small firms. And, during recessions, increase in large firms' tail risk is observed to be more than the small firms' risk.

Using the same time-varying but for specific commodity price shock and stock markets, Awartani and Maghyereh (2013) and Antonakakis, Chatziantoniou and Filis (2017) observed the dynamic spillovers connecting the shocks in the oil market and stock markets. Similarly, Balcilar, Hammoudeh and Asaba (2015) studied the transmission of information among oil prices, precious metal prices, and exchange rate. Awartani and Maghyereh (2013) investigated the spillover effects between oil price shocks and the stock markets of the Gulf Cooperation Council (GCC) countries for the period 2004-2012. Using the Diebold and Yilmaz (2012) approach, the finding indicates that return and volatility spillovers are bi-directional and asymmetric in nature. In returns and volatilities, the evidence suggests that the oil market receives from other markets less than what it gives especially after the GFC in 2008. In a similar dimension, Antonakakis, Chatziantoniou and Filis (2017) employs the oil supply-demand dynamics and the demand shocks of the sampled net oil-exporting and net-importing countries for the period 1995:09-2013:07. By extending the Diebold and Yilmaz (2014) approach, their investigation affirms that the returns and volatility of stock market spillovers are time-variant. Notably, the main transmitter of shocks to the stock markets is observed to be the aggregate demand shocks. But the periods of geopolitical unrest is characterized by the transmission of shocks to the stock markets by the supply-related and demand shocks.

Moreover, using a dynamic stochastic general equilibrium (DSGE), Iacoviello and Neri (2010) empirically showed that the housing market spillovers are non-negligible, consumption-concentrated, and rarely a business investment, further studies have revealed the spillovers (of returns and volatilities) in the housing market (Tsai, 2015; Antonakakis & Floros, 2016; Lee & Lee, 2018). Interestingly, Iacoviello and Neri (2010) found that the housing demand, the housing technology shocks, and the monetary factors respectively explains 25 percent, 25 percent and 20 percent of each volatility of the housing investment and the housing prices. However, the role of the monetary factors in the housing cycle over the past century is observed to more substantial. Using the Diebold and Yilmaz (2012) of the generalized VAR (Vector Autoregression) approach, Tsai (2015) reveals that shock information is differently transmitted between the real estate and the stock markets during each of normal periods and financial crisis periods. It further shows that the housing market conveys information to the stock market during normal periods, while the financial crisis periods are characterized by the stock market net spillover of information. Similarly, using the case of United Kingdom (UK) for the period 1997 M1 – 2015 M02, Antonakakis and Floros (2016) found the contagion from the housing and financial crisis to the real economy. In evidence, the study shows enormous spillover of shocks from the economic policy uncertainty, stock market, and the housing market to monetary policy stance, economic growth, and inflation. In relation to other studies, the study maintains that the volatility of in the UK's economy are evidence of shocks transmission which also varies over time. Additionally, Lee and Lee (2018) recently applied Diebold and Yilmaz (2012, 2015) to study the housing market volatility spillovers among G7 countries over the period 1970-2014. The evidence of degree of volatility interdependency over the business cycle especially with a surge during the GFC is similar to the aforementioned studies. The peculiarity of the Lee and Lee (2018) study is that it recognizes the US and Italy as the respective major net transmitters of volatility shocks in the housing market to other countries during the GFC and the European debt crisis.

5.3 Data and Empirical Estimation

We collect daily series of the agricultural commodity prices for Soybeans, Corn, and wheat (non-seasonally adjusted Producer Price Index, index 1982 = 100), the US total market index of Real Estate Investment Trust (REIT, proxy for housing market and not seasonally adjusted), the renewable energy equity[11] (in the US dollars), Crude oil prices (West Texas International (WTI) and Brent Crude, measured in US dollars per Barrel) over the daily period January 20, 2012 to August 2, 2018. Like the study of Tsai (2015), the stock market price index (by S&P500 and NASDAQ) are applied as control variables. While the dataset of the renewable energy equity is retrieved from the DataStream, other datasets are collected from the Federal Reserve Bank of St. Louis (FRED). After computing the level descriptive statistics of the series (see upper Table 10), we compute the first difference (Δ) of the returns of the series (r_t) (essentially to render the series stationary) of the natural logarithmic values of the series (S_t) for time t, such that

$$r_t = 100 * [\Delta \log(S_t)] \tag{1}$$

Again, we compute the volatility of the series from the return estimations from equation (1). In doing so, the series returns is regressed on the lag value of the series consecutively. Hence, the volatility series is obtained from EGARCH (p, q) where p and q are the lag values such that the common statistics of the returns and volatility series are also present in Table 10 (middle and bottom respectively).

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[11] Renewable energy equity is the aggregate equities of the renewable energy market from the Thomson Reuters DataStream.

Table 10: Descriptive Statistics (Levels, Returns, and Volatility)

Variable	**Mean**	**Maximum**	**Minimum**	Standard Dev	**Skewness**	**Kurtosis**	SSD	**Observations**
Wheat	5.54955	9.140000	3.260000	1.378616	0.677497	2.334214	3107.452	1636
Corn	4.43932	8.49000	2.790000	1.511770	1.136639	2.752206	3736.708	1636
Sbeans	11.42112	17.90000	7.840000	2.506784	0.617522	2.000673	10274.29	1636
Renewable	10.20077	18.20000	4.600000	2.605119	0.551461	3.641847	11096.16	1636
WTI	70.64891	110.6200	26.19000	24.08109	0.128501	1.441388	948134.6	1636
Brent	77.30312	128.1400	26.01000	28.56144	0.123797	1.404764	1333761	1636
REIT	8143.733	10343.63	5591.380	1370.860	-0.230504	1.625912	3.07E+09	1636
S&P 500	2003.387	2872.870	1278.040	402.6002	0.120974	2.294185	2.65E+08	1636
NASDAQ	4778.262	7932.240	2747.480	1316.900	0.436312	2.456764	2.84E+09	1636
				Returns				
Wheat	0.092914	49.57662	-50.5939	8.688681	0.257892	7.116601	118599.8	1572
Corn	-0.06606	35.18677	-34.0258	5.765055	0.088556	12.28211	52213.53	1572
Sbeans	-0.11879	98.21836	-139.712	18.36424	-0.61013	10.10796	529812.2	1572
Renewable	0.764279	197.1507	-247.511	31.15916	0.182313	13.17848	1525273	1572
WTI	-0.28132	1412.484	-1207.30	223.8984	0.005479	5.271186	7875502	1572
Brent	-3.27479	921.7796	-1042.87	226.1803	-0.07585	4.305698	80368473	1572
REIT	951.6780	99400.06	-158265	29543.71	-0.47595	5.054160	1.37E+12	1572
S&P 500	321.1397	24071.83	-38745.8	5181.515	-0.75249	8.481974	4.22E+10	1572
NASDAQ	1148.415	87925.23	-105285	16698.09	-0.66559	7.626624	4.38E+11	1572
				Volatility				
Wheat	73.71612	411.3041	13.62085	63.53579	2.511068	10.52967	6870627	1703
Corn	33.52751	389.3127	1.884149	53.66813	3.217958	15.66618	4902217	1703
Sbeans	342.4702	3860.470	32.98029	423.1509	3.961207	23.36834	3.05E+08	1703
Renewable	905.9236	3525.085	385.2254	547.0060	2.099559	7.334029	5.09E+08	1703
WTI	47247.05	145116.3	11920.52	22383.11	0.892338	3.556559	8.53E+11	1703
Brent	47632.13	126947.0	18402.53	19991.21	1.368626	4.992017	4.05E+20	1703
REIT	8.31E+08	2.97E+09	2.40E+08	4.88E+08	1.230504	1.625912	3.07E+09	1703
S&P 500	24585912	3.96E+08	5191366	27732579	6.042913	58.67918	1.31E+18	1703
NASDAQ	2.50E+08	3.01E+09	3881292	2.41E+08	4.414878	32.50099	9.86E+19	1703

Note: A lag selection by SIC and AIC (maxlag=1). SSD is the Sum of Squared Deviation. Originally, the number of observations including missing dates is 170.

5.3.1 Empirical Estimation

The current study employs the unique technique of Diebold and Yilmaz (2012) which is based on the generalized VAR model and insensitivity to variable ordering. In this approach, the Total, Directional, Net, and Net Pairwise Spillovers are the categories of spillover obtainable. Hence, a covariance stationary VAR (p) is considered

$$y_t = \sum_{i=1}^{p} \Phi_i y_{t-1} + \varepsilon_t \sim (0, \Sigma) \tag{2}$$

such that the moving average of the covariance stationary process of equation (2) above is

$$y_t = \sum_{i=0}^{\infty} A_i \varepsilon_{t-1} \tag{3}$$

where $y_t = y_{1t}, y_{2t}, ..., y_{Nt}'$ is N x 1 vector of the individual return and volatility series (vector endogenous variables), given that Φ is N x N , ε is the vector of disturbance that are assumed to be independent (not necessarily identically) distributed over time, A (of equation 2) is assumed to follow the recursion $A_i = \phi_1 A_{i-1} + \phi_2 A_{i-2} + ... + \phi_p A_{i-p}$, A_0 is the identity matrix (of *N* x *N* dimension), and $A_i = 0$ for all $i < 0$.

In the process of assessing the magnitude of the market spillovers as our priority instead of determining the causal effects of structural shocks, we adopt the conventional VAR framework such that the H-step-ahead forecast error variance contribution becomes

$$\theta_{ij}^{g}(H) = \frac{\sigma_{jj}^{-1} \sum_{h=0}^{H-1} (e_i' A_h \Sigma e_j)^2}{\sum_{h=0}^{H-1} (e_i' A_h \Sigma A_h e_i')^2} \tag{4}$$

So that the variance matrix of the error vector is Σ, σ_{jj} is the standard deviation of the error term for variable *j*, e_i is the selection vector with *1 = ith* element and *0* = otherwise. Then, the diagonally centralized elements (the own variance shares of shocks to variable y_i) is the fraction of the H-step-ahead error variance in forecasting y_i, given that *i* = 1, 2, … *N*. Also, the off-diagonal (cross variance shares or spillovers) are the fractions of the H-step-ahead error variances in forecasting *y*i that are due to shocks to y_j, given that *j* = 1, 2, … *N* and *i* is not equal *j*. Furthermore, to use the full information, each entry of the variance decomposition matrix is normalized by taking the row sum such that

$$\bar{\theta}_{ij}^{g}(H) = \frac{\theta_{ij}^{g}(H)}{\sum_{j=1}^{N} \theta_{ij}^{g}} \tag{5}$$

where $\sum_{j=1}^{N} \theta_{ij}^{g}(H)$ (sum of the contributions to the variance of the forecast error) is

not equal to 1, but $\sum_{j=1}^{N} \overline{\theta}_{ij}^{g}(H) = 1$ and $\sum_{i,j=1}^{N} \tilde{\theta}_{ij}^{g}(H) = N$ by the construction.

In respect to the aforementioned estimations steps, the Total spillover index (is directional spillover that specifically quantifies the contribution of spillovers (return and volatility shocks) among the examined commodity markets is provided as

$$S^{g}(H) = \frac{\sum_{\substack{i,j=1 \\ i \neq j}}^{N} \overline{\theta}_{ij}^{g}(H)}{\sum_{i,j=1}^{N} \overline{\theta}_{ij}^{g}(H)} \times 100 = \frac{\sum_{\substack{i,j=1 \\ i \neq j}}^{N} \overline{\theta}_{ij}^{g}(H)}{N} \times 100 \tag{6}$$

Also, the Total directional spillover exhibits two indicators: "To others" and "From other". While the directional spillover index from others is computed as

$$S_i^g(H) = \frac{\sum_{\substack{J=1 \\ j \neq 1}}^{N} \bar{\theta}_{ij}^{g}(H)}{\sum_{i,J=1}^{N} \bar{\theta}_{ij}^{g}(H)} \times 100 = \frac{\sum_{\substack{J=1 \\ j \neq 1}}^{N} \bar{\theta}_{ij}^{g}(H)}{N} \times 100\,, \tag{7}$$

the directional spillover index to others is calculated as

$$S_i^g(H) = \frac{\sum_{\substack{J=1 \\ j \neq 1}}^{N} \bar{\theta}_{ji}^{g}(H)}{\sum_{i,J=1}^{N} \bar{\theta}_{ji}^{g}(H)} \times 100 = \frac{\sum_{\substack{J=1 \\ j \neq 1}}^{N} \bar{\theta}_{ji}^{g}(H)}{N} \times 100 \tag{8}$$

Moreover, the difference between the ‘to other’ and ‘from others’ indicators is calculated using

$$S_{i}^{g}(H) = S_{.i}^{g}(H) - S_{i.}^{g}(H) \tag{9}$$

So that, the net pairwise directional spillovers is also computed from

$$S_{ij}^{g}(H) = \{\frac{\bar{\theta}_{ji}^{g}(H)}{\sum_{i,\mathrm{k}=1}^{N} \bar{\theta}_{ik}^{g}(H)} - \frac{\bar{\theta}_{ij}^{g}(H)}{\sum_{\mathrm{j,k}=1}^{N} \bar{\theta}_{jk}^{g}(H)}\} \times 100 = \{\frac{\bar{\theta}_{ji}^{g}(H) - \bar{\theta}_{ij}^{g}(H)}{N}\} \times 100 \tag{10}$$

Considering that Salisu, Oyewole and Fasanya (2018) adopted the Diebold and Yilmaz (2012) to investigate the returns and volatility spillovers of the six (6) global foreign exchange markets while several studies have also considered inter-market spillovers (Antonakakis & Floros, 2016; Lee & Lee, 2018), hence the concept of aforesaid studies is advanced. In the current study, we measuring the total spillover index, the contributions of spillovers of return and that of volatility shocks to the total forecast error variance is the main priority. The study employs nine (9) components of the US markets (stock, energy, housing, and agricultural commodity). As revealed, the Tables 11a, 11b, 11c are the categories (level, returns and volatility series) of spillover indices.

Table 11a: The Directional Spillover Results at Level

Variable	**1**	2	3	4	5	6	7	8	9	Contribution from others	Net spillover
1	**99.0**	0.2	0.2	0.0	0.2	0.0	0.2	0.1	0.1	1.0	42.7
2	28.0	**71.6**	0.2	0.1	0.0	0.0	0.0	0.1	0.0	28.4	-5.4
3	14.6	19.8	**65.3**	0.1	0.2	0.1	0.0	0.0	0.0	34.7	-26.2
4	0.1	0.1	0.1	**98.3**	0.5	0.9	0.0	0.0	0.0	1.7	26.3
5	0.2	1.5	3.2	6.6	**87.9**	0.5	0.1	0.0	0.1	12.1	50.4
6	0.6	1.4	2.0	3.3	52.6	**39.7**	0.2	0.1	0.0	60.3	-58
7	0.0	0.1	0.8	3.1	0.7	0.1	**94.9**	0.1	0.2	5.1	46.7
8	0.2	0.1	1.3	7.8	5.7	0.3	28.9	**55.5**	0.3	44.5	9.2
9	0.0	0.0	0.8	6.8	2.7	0.5	22.3	53.2	**13.7**	86.3	-85.5
Contribution to others	43.7	23.0	8.5	28.0	62.5	2.3	51.8	53.7	0.8	274.2	
										Total	
Contribution including own	142.7	94.6	75.6	126.2	150.3	42.1	146.7	109.1	14.5	{**30.5%**}	

Note: Wheat=1, Corn=2, Sbeans=3, renewable=4, WTI=5, Brent=6, REIT=7, S&P 500=8, NASDAQ=9 Lag length by AIC selection = 2

Table 11b: The Directional Returns Spillover

Variable	**1**	2	3	4	5	6	7	8	9	Contribution from others	Net spillover
1	**99.4**	0.0	0.3	0.0	0.2	0.1	0.0	0.0	0.0	0.6	43.9
2	29.5	**70.2**	0.0	0.0	0.1	0.0	0.0	0.0	0.0	29.8	-13.1
3	13.6	15.0	**71.0**	0.1	0.1	0.0	0.0	0.0	0.0	29.0	-24.4
4	0.0	0.3	0.0	**99.5**	0.1	0.0	0.0	0.0	0.0	0.5	17.3
5	0.5	0.7	1.5	2.5	**94.7**	0.0	0.0	0.0	0.0	5.3	39.8
6	0.2	0.6	1.0	1.7	36.6	**59.6**	0.0	0.2	0.0	40.4	-40
7	0.3	0.0	0.3	2.6	0.8	0.1	**95.7**	0.2	0.1	4.3	40.9
8	0.2	0.0	0.9	5.9	4.9	0.2	26.2	**61.7**	0.1	38.3	22.9
9	0.1	0.0	0.6	5.0	2.3	0.1	18.9	60.8	**12.2**	87.8	-87.3
Contribution to others	44.5	16.7	4.6	17.8	45.1	0.4	45.2	61.2	0.5	236.0	
										Total	
Contribution including own	143.9	86.9	75.6	117.3	139.8	60.0	140.9	122.9	12.6	{**26.2%**}	

Note: Wheat=1, Corn=2, Sbeans=3, renewable=4, WTI=5, Brent=6, REIT=7, S&P 500=8, NASDAQ=9 Lag length by AIC selection = 1.

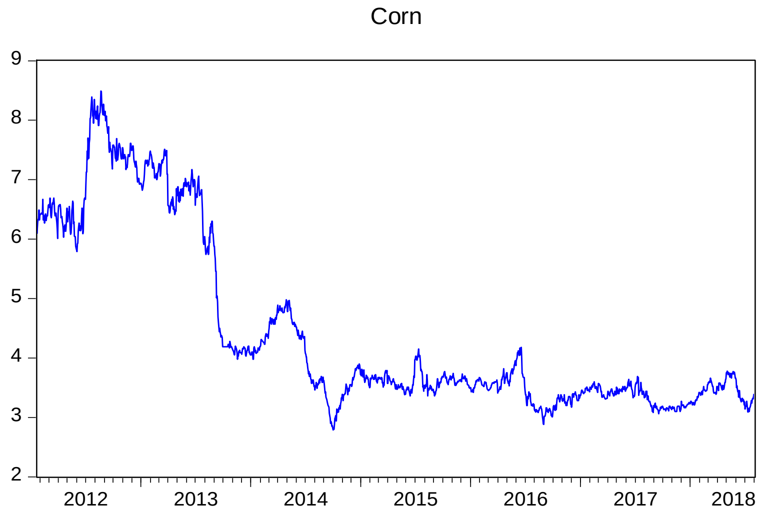
Table 11c: The Directional Volatility Spillover

Variable	**1**	2	3	4	5	6	7	8	9	Contribution from others	Net spillover
1	**97.6**	0.6	0.0	0.1	0.1	0.8	0.4	0.1	0.3	2.4	26.6
2	18.3	**78.6**	0.8	0.1	0.7	1.0	0.3	0.0	0.1	21.4	9.3
3	7.5	27.8	**62.3**	0.0	1.3	0.4	0.3	0.1	0.2	37.7	-36
4	0.1	0.4	0.0	**98.8**	0.0	0.0	0.5	0.2	0.1	1.2	0.9
5	0.3	1.0	0.0	0.0	**97.6**	0.2	0.0	0.8	0.0	2.4	24.4
6	2.1	0.8	0.7	0.0	19.8	**76.0**	0.3	0.2	0.1	24.0	-21.4
7	0.6	0.0	0.0	0.4	2.2	0.1	**94.7**	1.9	0.1	5.3	32.1
8	0.0	0.0	0.0	0.8	1.7	0.1	19.9	**77.4**	0.0	22.6	52.1
9	0.0	0.1	0.0	0.7	1.0	0.0	15.6	71.4	**11.2**	88.8	-87.8
Contribution to others	29.0	30.7	1.7	2.1	26.8	2.6	37.4	74.7	1.0	205.9	
										Total	
Contribution to others	126.6	109.3	63.9	100.8	124.3	78.6	132.1	152.1	12.2	{**22.9%**}	

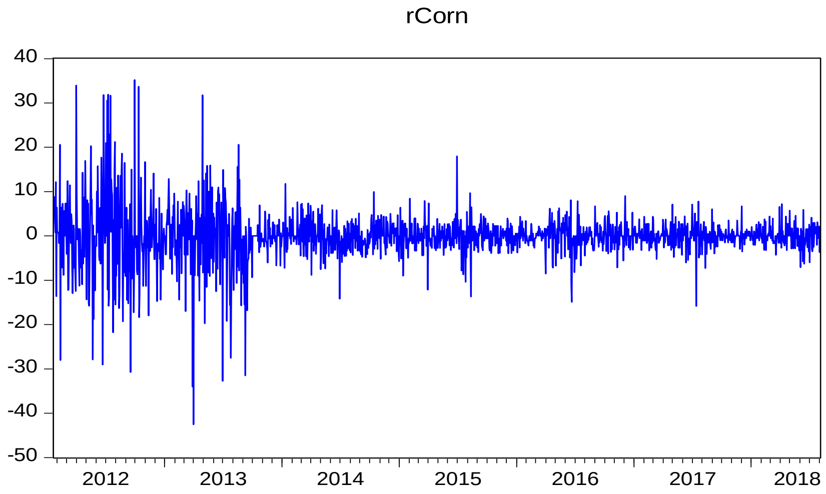
Note: Wheat=1, Corn=2, Sbeans=3, renewable=4, WTI=5, Brent=6, REIT=7, S&P 500=8, NASDAQ=9 Lag length selection by SIC (lag=1).

5.4 Empirical Results and Discussion

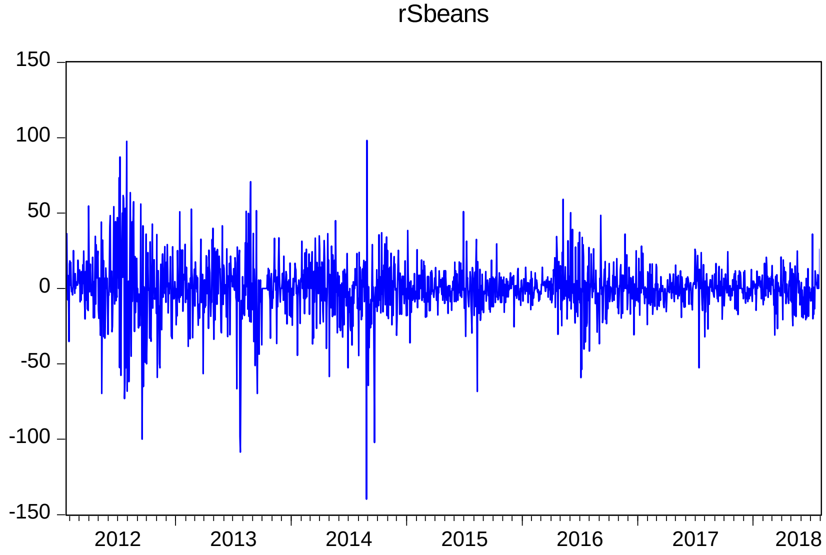
In Table 10, the common statistics of the series for before computations, for returns, and volatility estimates are presented. The return estimates as contained in the middle section of Table 10 is for the entire period. In this part, the average returns of each series over the estimated period is the mean. Positive average returns are observed for *wheat, renewables, REIT, S&P500* and *NASDAQ,* while *corn, sbeans, WTI,* and *crude Brent* exhibits negative average returns. The dynamics of the returns of all the series are displayed as Figure 7 (for a-i). From the observation of Table 10 as further illustrated in the aforesaid Figures, the returns of all the series are skewed except the Sbeans which apparently have a symmetric mean (skewness of -0.61013) compared to the mean of -0.11879. Also, the kurtosis statistics implies that the returns of the series are at least peaked (leptokurtic).


Corn
9
8
7
6
5
4
3
2
2012
2013
2014
2015
2016
2017
2018

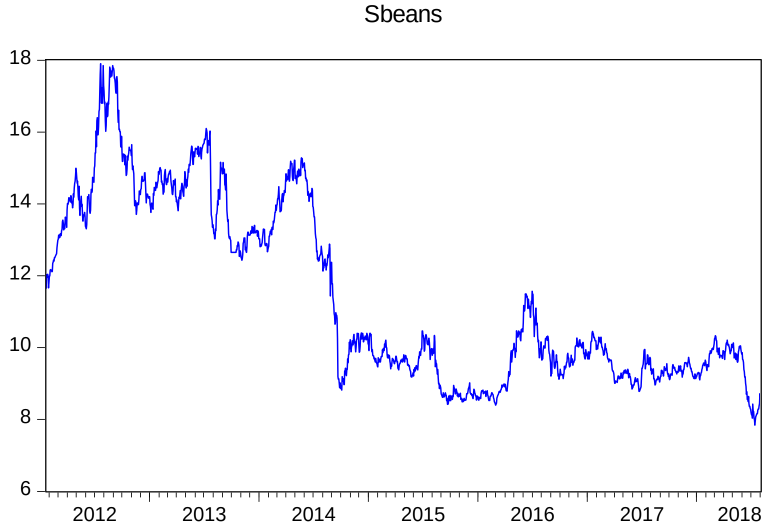
(a1)


rCorn
40
30
20
10
0
-10
-20
-30
-40
-50
2012
2013
2014
2015
2016
2017
2018

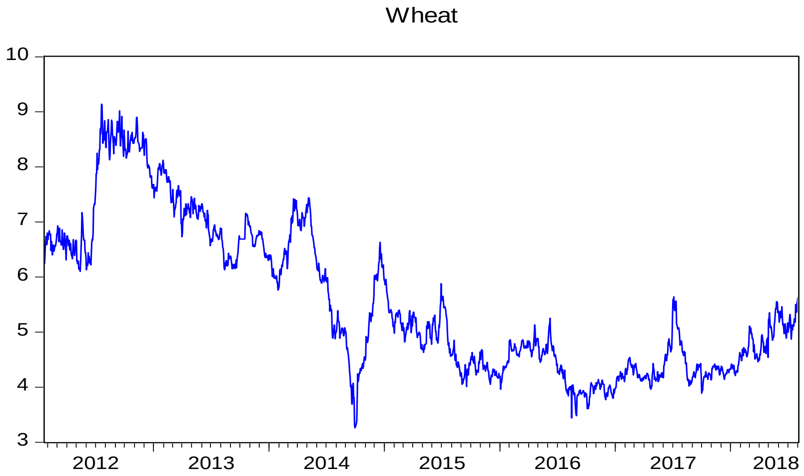
(a2)


rSbeans
150
100
50
0
-50
-100
-150
2012
2013
2014
2015
2016
2017
2018

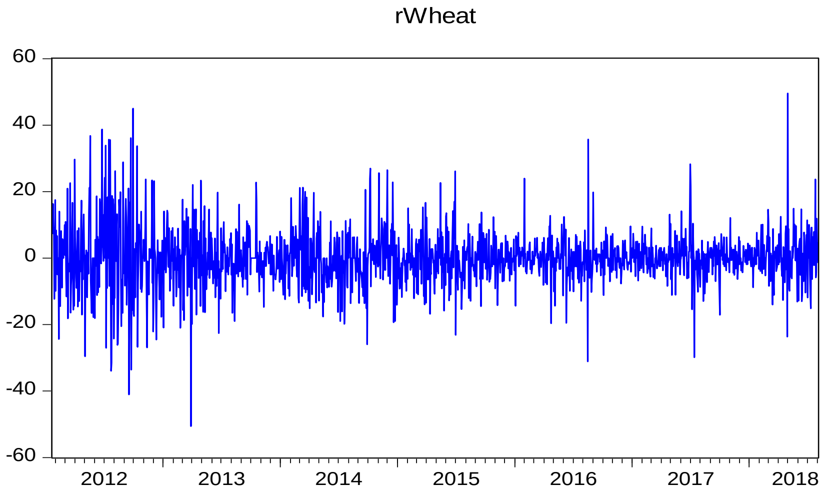
(b2)


Sbeans
18
16
14
12
10
8
6
2012
2013
2014
2015
2016
2017
2018

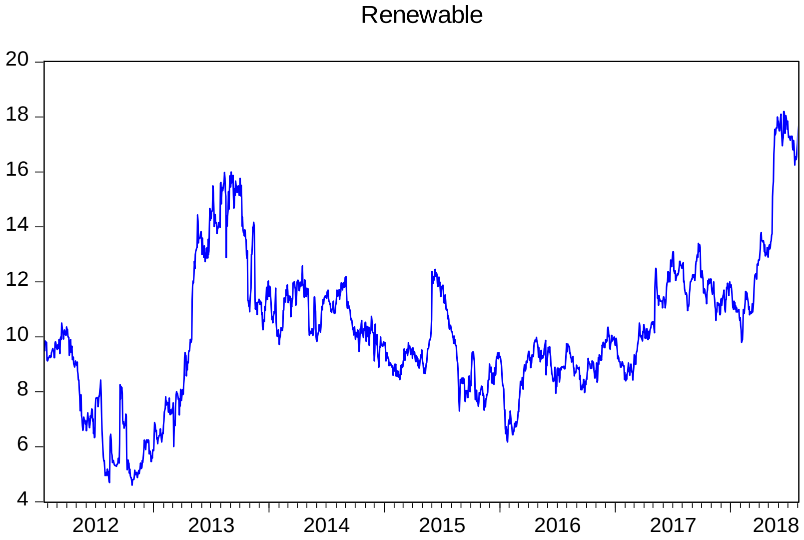
(b1)


Wheat
10
9
8
7
6
5
4
3
2012
2013
2014
2015
2016
2017
2018

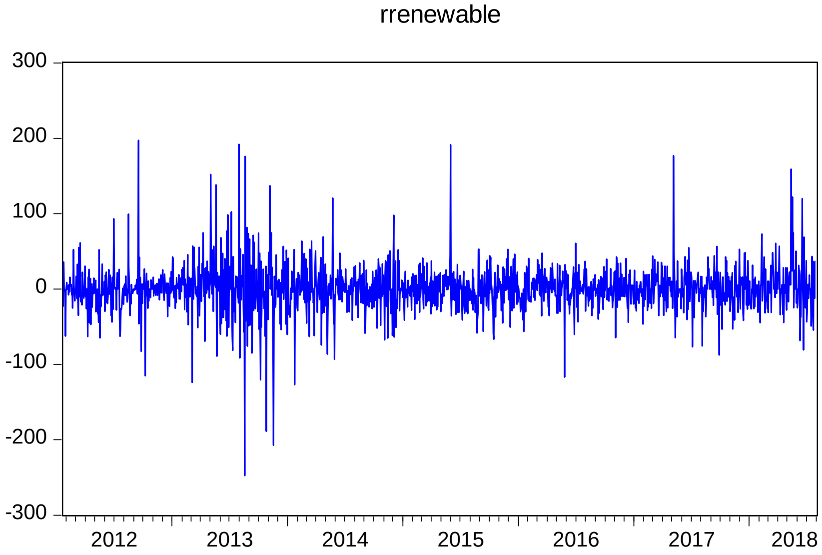
(c1)


rWheat
60
40
20
0
-20
-40
-60
2012
2013
2014
2015
2016
2017
2018

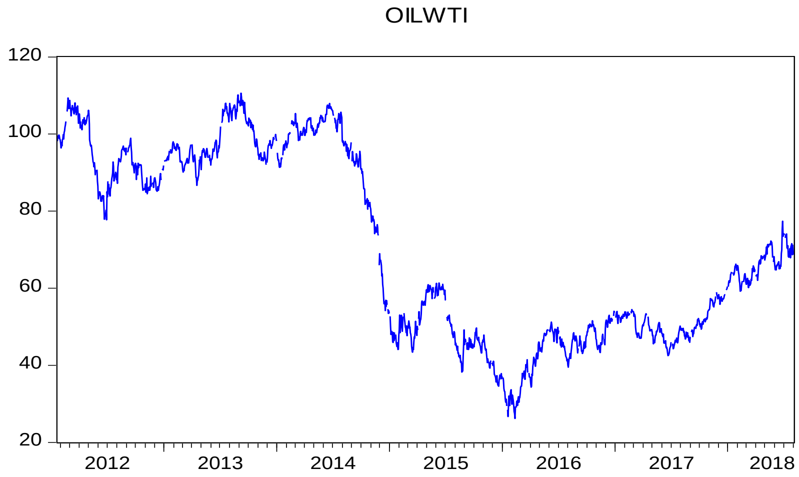
(c2)


Renewable
20
18
16
14
12
10
8
6
4
2012
2013
2014
2015
2016
2017
2018

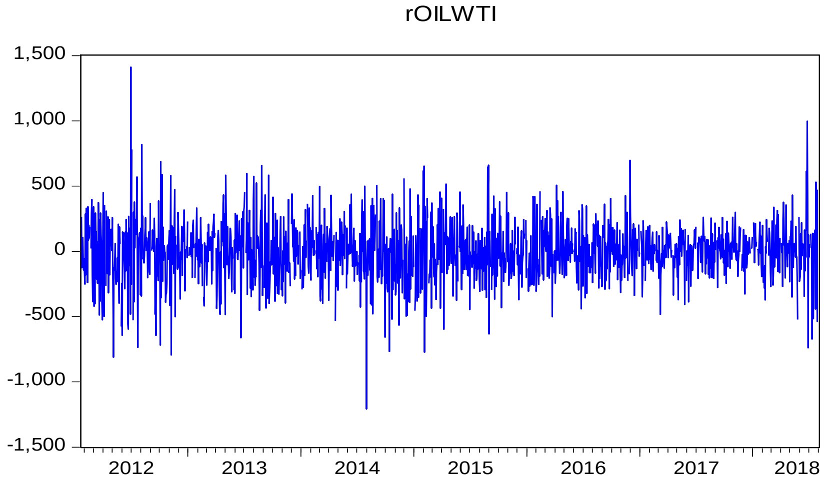
(d1)


rrenewable
300
200
100
0
-100
-200
-300
2012
2013
2014
2015
2016
2017
2018

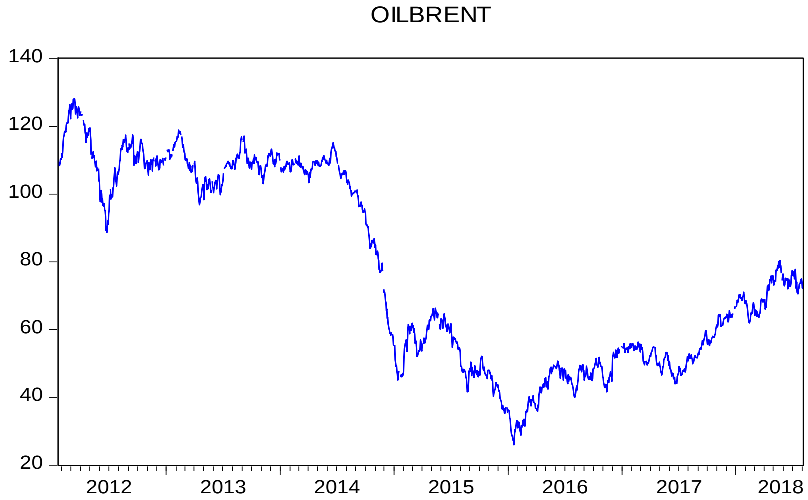
(d2)


OILWTI
120
100
80
60
40
20
2012
2013
2014
2015
2016
2017
2018

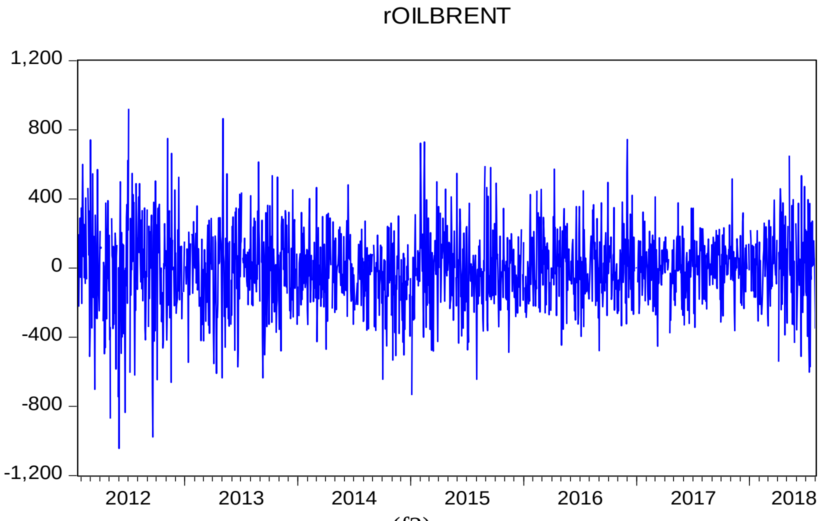
(e1)


rOILWTI
1,500
1,000
500
0
-500
-1,000
-1,500
2012
2013
2014
2015
2016
2017
2018

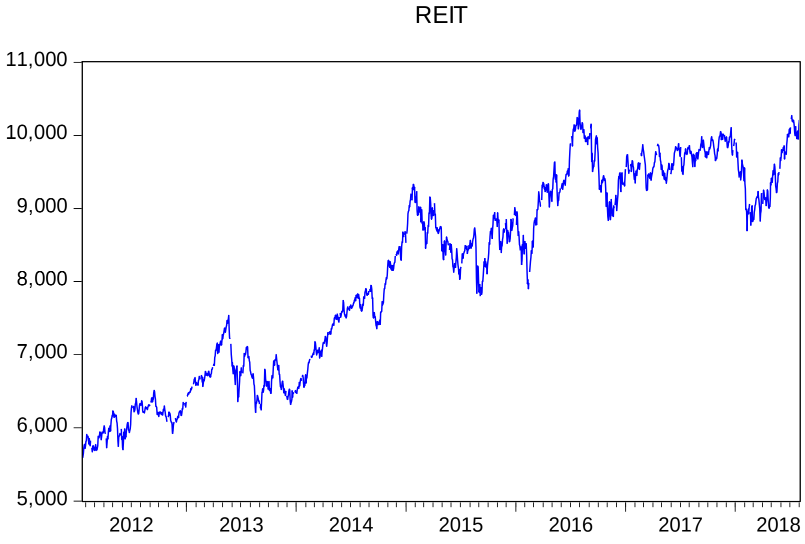
(e2)


OILBRENT
140
120
100
80
60
40
20
2012
2013
2014
2015
2016
2017
2018

(f1)

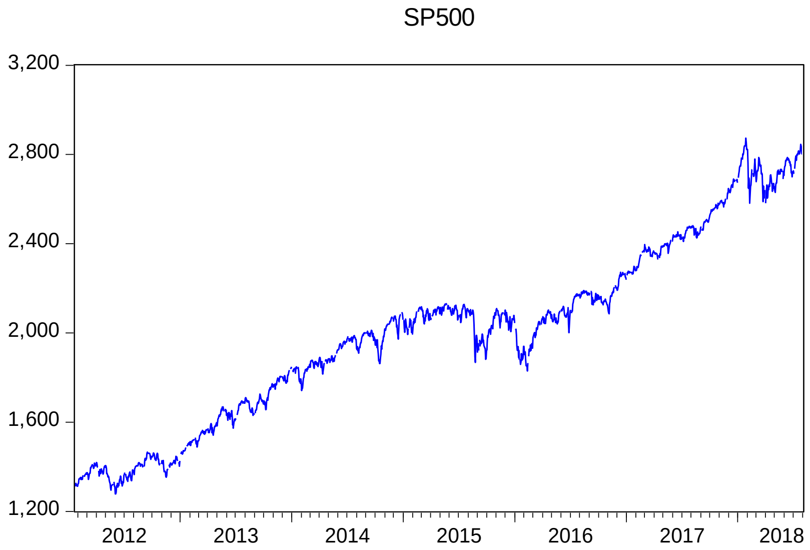

rOILBRENT
1,200
800
400
0
-400
-800
-1,200
2012
2013
2014
2015
2016
2017
2018

(f2)

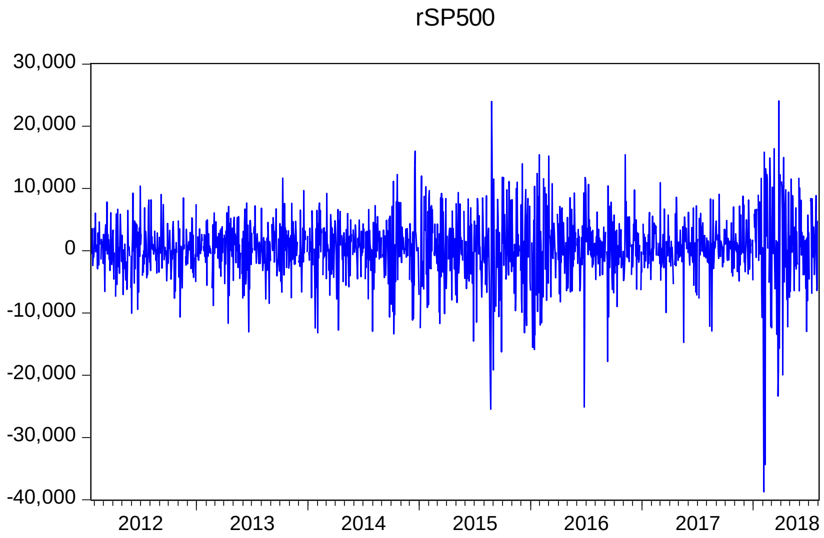

REIT
11,000
10,000
9,000
8,000
7,000
6,000
5,000
2012
2013
2014
2015
2016
2017
2018

(g1)

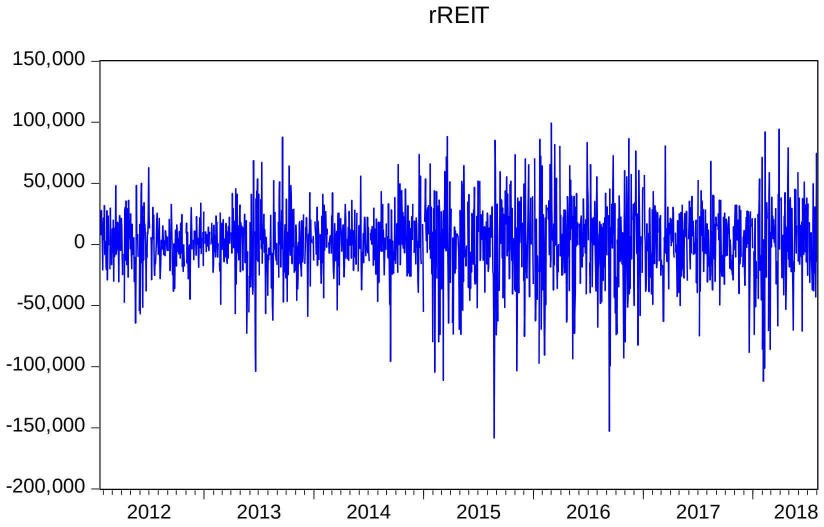
(g2)

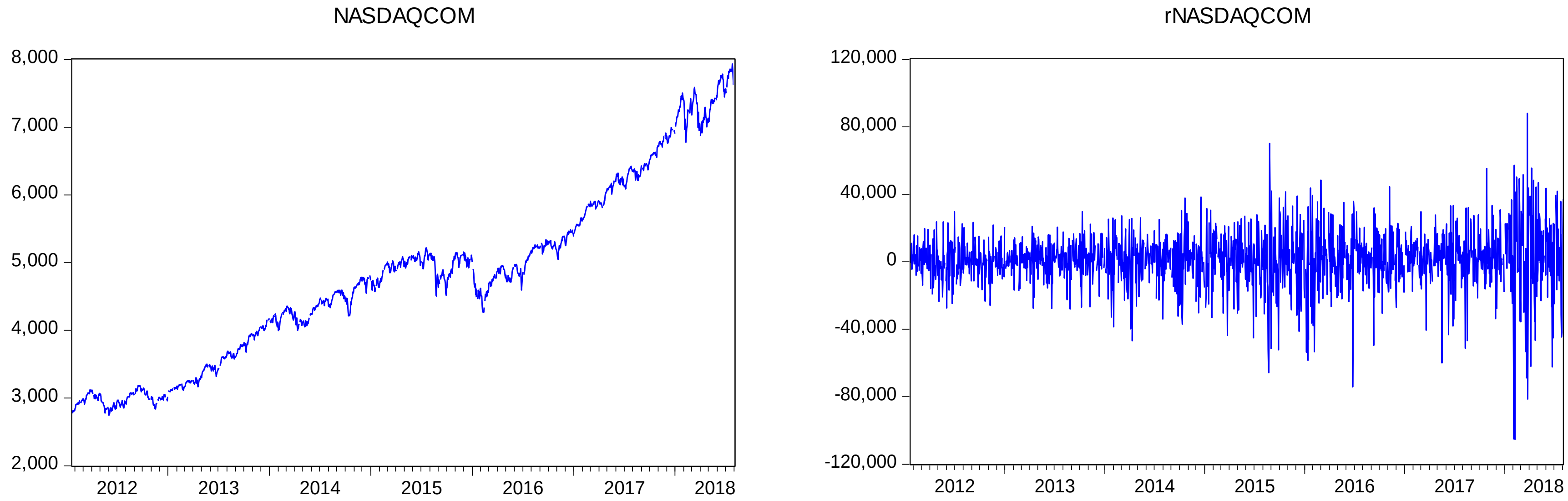

SP500
3,200
2,800
2,400
2,000
1,600
1,200
2012
2013
2014
2015
2016
2017
2018

(h1)


rSP500
30,000
20,000
10,000
0
-10,000
-20,000
-30,000
-40,000
2012
2013
2014
2015
2016
2017
2018

(h2)

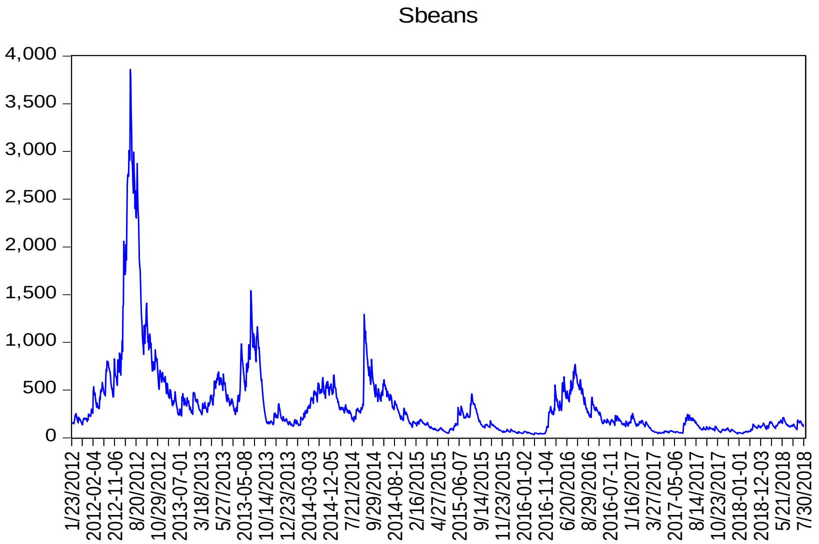

rREIT
150,000
100,000
50,000
0
-50,000
-100,000
-150,000
-200,000
2012
2013
2014
2015
2016
2017
2018



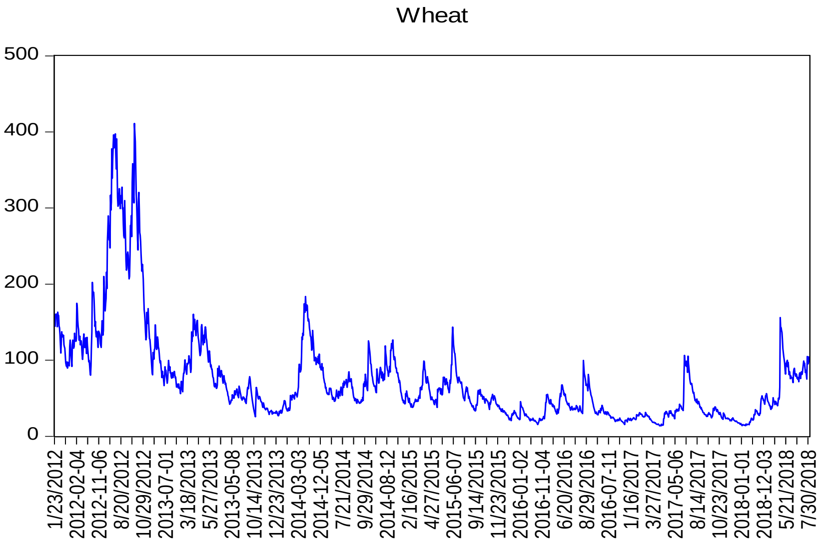
(i1) (i2)

Figure 7: Plots (a-i) for Series (left) and Returns (right) of Series.

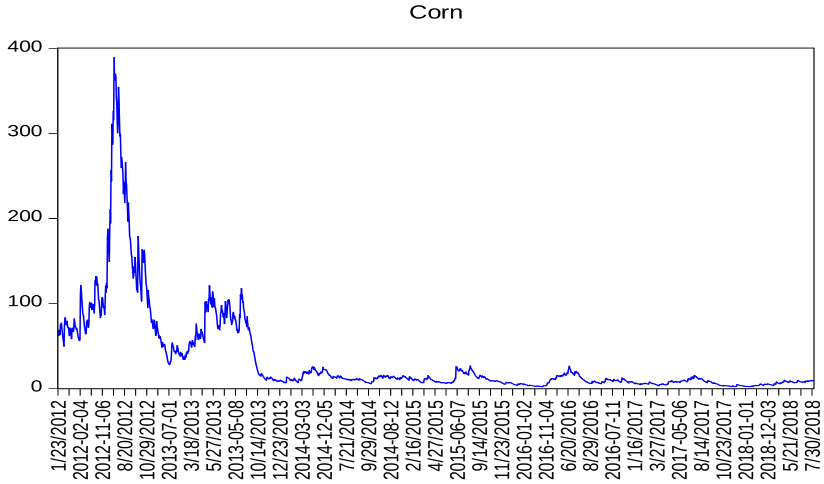
Again, the lower part of Table 10 depicts the descriptive statistics for the volatility series of all variables under the whole sample period. Giving the Figure 8 (of 1-9), there is significant evidence showing time events of high volatility are immediately followed by time events of relatively low volatility. As observed from the volatility statistics, all the significantly deviates from the mean, positively skewed, and the evidence is corroborated by the volatility Figures.


Sbeans
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1/23/2012
2012-02-04
2012-11-06
8/20/2012
10/29/2012
2013-07-01
3/18/2013
5/27/2013
2013-05-08
10/14/2013
12/23/2013
2014-03-03
2014-12-05
7/21/2014
9/29/2014
2014-08-12
2/16/2015
4/27/2015
2015-06-07
9/14/2015
11/23/2015
2016-01-02
2016-11-04
6/20/2016
8/29/2016
2016-07-11
1/16/2017
3/27/2017
2017-05-06
8/14/2017
10/23/2017
2018-01-01
2018-12-03
5/21/2018
7/30/2018

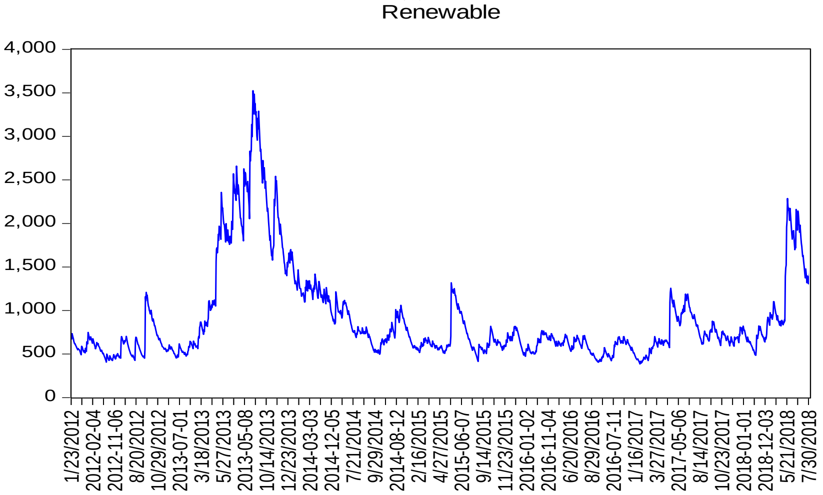
(1)


Wheat
500
400
300
200
100
0
1/23/2012
2012-02-04
2012-11-06
8/20/2012
10/29/2012
2013-07-01
3/18/2013
5/27/2013
2013-05-08
10/14/2013
12/23/2013
2014-03-03
2014-12-05
7/21/2014
9/29/2014
2014-08-12
2/16/2015
4/27/2015
2015-06-07
9/14/2015
11/23/2015
2016-01-02
2016-11-04
6/20/2016
8/29/2016
2016-07-11
1/16/2017
3/27/2017
2017-05-06
8/14/2017
10/23/2017
2018-01-01
2018-12-03
5/21/2018
7/30/2018

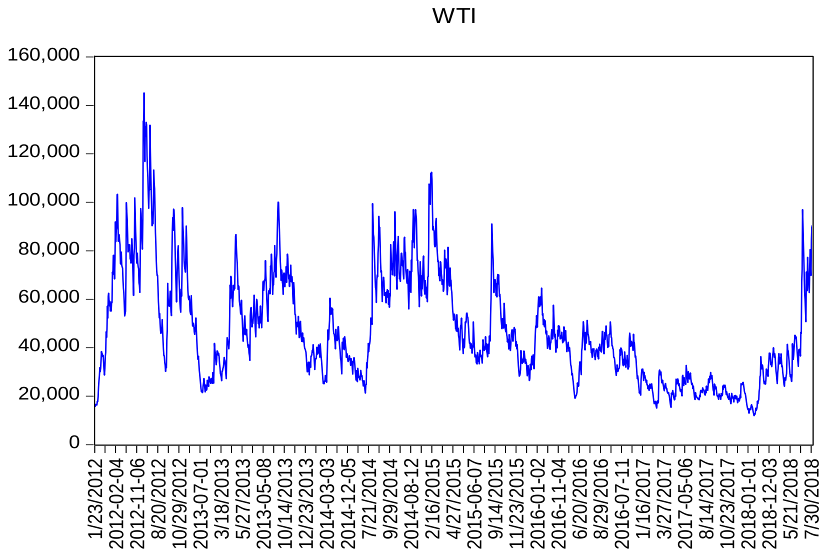
(3)


Corn
400
300
200
100
0
1/23/2012
2012-02-04
2012-11-06
8/20/2012
10/29/2012
2013-07-01
3/18/2013
5/27/2013
2013-05-08
10/14/2013
12/23/2013
2014-03-03
2014-12-05
7/21/2014
9/29/2014
2014-08-12
2/16/2015
4/27/2015
2015-06-07
9/14/2015
11/23/2015
2016-01-02
2016-11-04
6/20/2016
8/29/2016
2016-07-11
1/16/2017
3/27/2017
2017-05-06
8/14/2017
10/23/2017
2018-01-01
2018-12-03
5/21/2018
7/30/2018

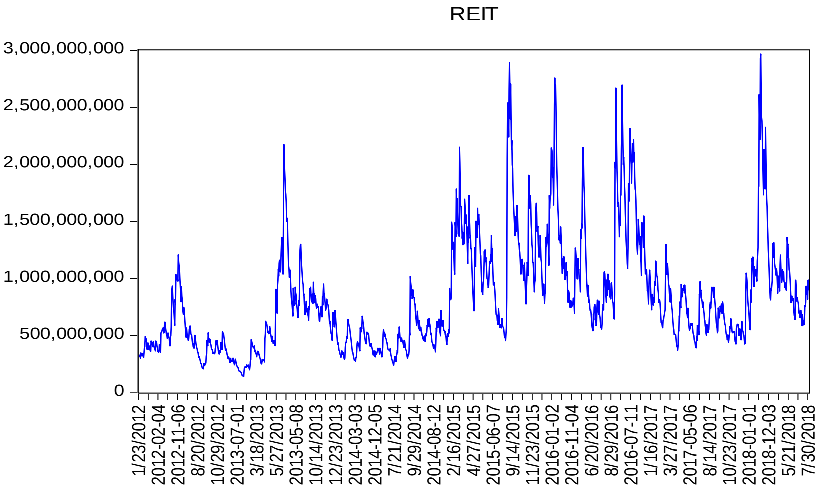
(2)


Renewable
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1/23/2012
2012-02-04
2012-11-06
8/20/2012
10/29/2012
2013-07-01
3/18/2013
5/27/2013
2013-05-08
10/14/2013
12/23/2013
2014-03-03
2014-12-05
7/21/2014
9/29/2014
2014-08-12
2/16/2015
4/27/2015
2015-06-07
9/14/2015
11/23/2015
2016-01-02
2016-11-04
6/20/2016
8/29/2016
2016-07-11
1/16/2017
3/27/2017
2017-05-06
8/14/2017
10/23/2017
2018-01-01
2018-12-03
5/21/2018
7/30/2018

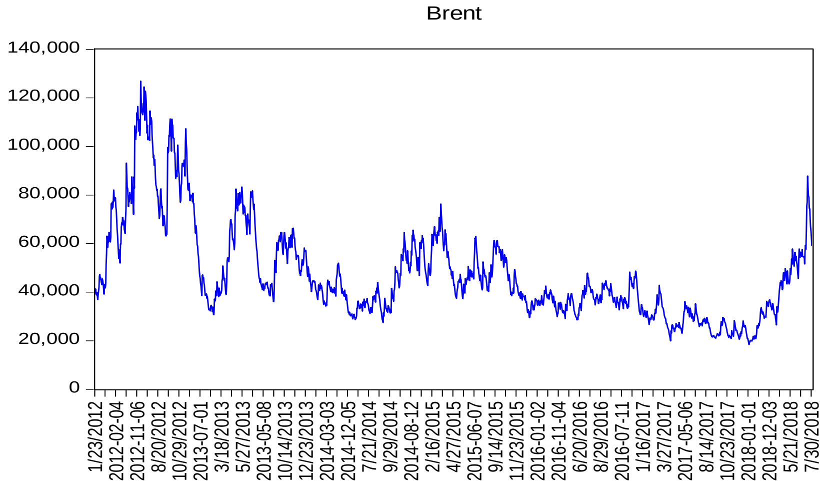
(5)


WTI
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
1/23/2012
2012-02-04
2012-11-06
8/20/2012
10/29/2012
2013-07-01
3/18/2013
5/27/2013
2013-05-08
10/14/2013
12/23/2013
2014-03-03
2014-12-05
7/21/2014
9/29/2014
2014-08-12
2/16/2015
4/27/2015
2015-06-07
9/14/2015
11/23/2015
2016-01-02
2016-11-04
6/20/2016
8/29/2016
2016-07-11
1/16/2017
3/27/2017
2017-05-06
8/14/2017
10/23/2017
2018-01-01
2018-12-03
5/21/2018
7/30/2018

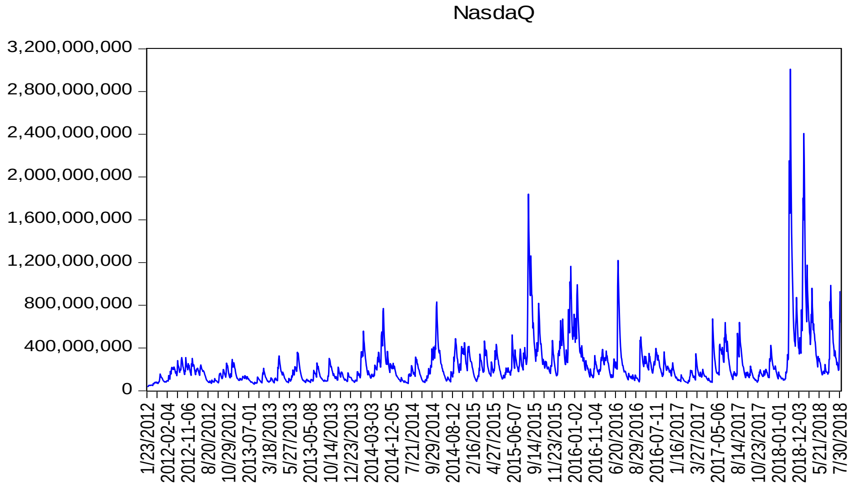
(4)


REIT
3,000,000,000
2,500,000,000
2,000,000,000
1,500,000,000
1,000,000,000
500,000,000
0
1/23/2012
2012-02-04
2012-11-06
8/20/2012
10/29/2012
2013-07-01
3/18/2013
5/27/2013
2013-05-08
10/14/2013
12/23/2013
2014-03-03
2014-12-05
7/21/2014
9/29/2014
2014-08-12
2/16/2015
4/27/2015
2015-06-07
9/14/2015
11/23/2015
2016-01-02
2016-11-04
6/20/2016
8/29/2016
2016-07-11
1/16/2017
3/27/2017
2017-05-06
8/14/2017
10/23/2017
2018-01-01
2018-12-03
5/21/2018
7/30/2018

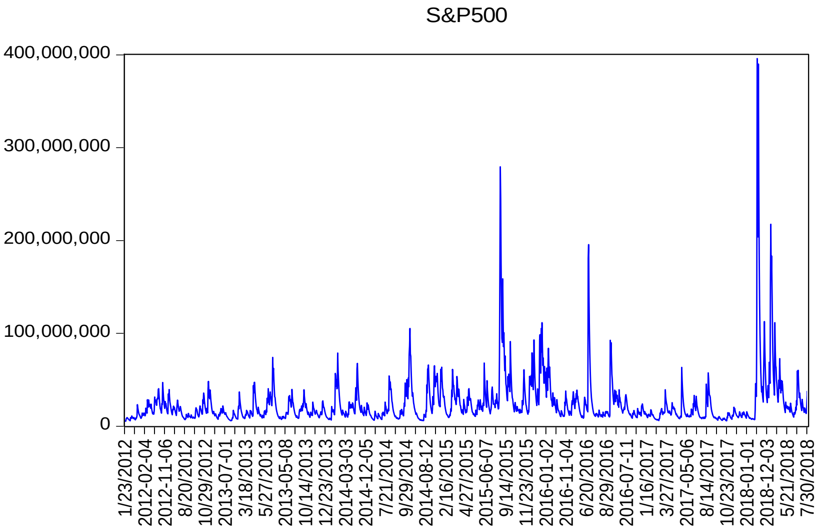
(7)


Brent
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
1/23/2012
2012-02-04
2012-11-06
8/20/2012
10/29/2012
2013-07-01
3/18/2013
5/27/2013
2013-05-08
10/14/2013
12/23/2013
2014-03-03
2014-12-05
7/21/2014
9/29/2014
2014-08-12
2/16/2015
4/27/2015
2015-06-07
9/14/2015
11/23/2015
2016-01-02
2016-11-04
6/20/2016
8/29/2016
2016-07-11
1/16/2017
3/27/2017
2017-05-06
8/14/2017
10/23/2017
2018-01-01
2018-12-03
5/21/2018
7/30/2018

(6)


NasdaQ
3,200,000,000
2,800,000,000
2,400,000,000
2,000,000,000
1,600,000,000
1,200,000,000
800,000,000
400,000,000
0
1/23/2012
2012-02-04
2012-11-06
8/20/2012
10/29/2012
2013-07-01
3/18/2013
5/27/2013
2013-05-08
10/14/2013
12/23/2013
2014-03-03
2014-12-05
7/21/2014
9/29/2014
2014-08-12
2/16/2015
4/27/2015
2015-06-07
9/14/2015
11/23/2015
2016-01-02
2016-11-04
6/20/2016
8/29/2016
2016-07-11
1/16/2017
3/27/2017
2017-05-06
8/14/2017
10/23/2017
2018-01-01
2018-12-03
5/21/2018
7/30/2018

(8)



(9)

Figure 8: Plots of Volatility Clustering (1-9) of the Return Volatility Series.

5.4.1 Spillover Indices

In estimating the Total connectedness (spillover index) for the whole sample of the natural form of the series, the returns, and the volatility series, the equation 6 (see above) is employed. The model selection is based on the Akaike Information Criterion (AIC) and Schwarz Information Criterion (SIC) of the VAR (1) model with 10-step-ahead forecasts horizon such that directional spillover indices are obtained as shown in Table 11a. In the indicated Table (11a), the connectedness of the natural series is 30% with high own-shares exhibited by Wheat, Corn, renewable, WTI, and REIT. A lower own-share is exhibited by Brent, NASDAQ, and moderately by S&P500.

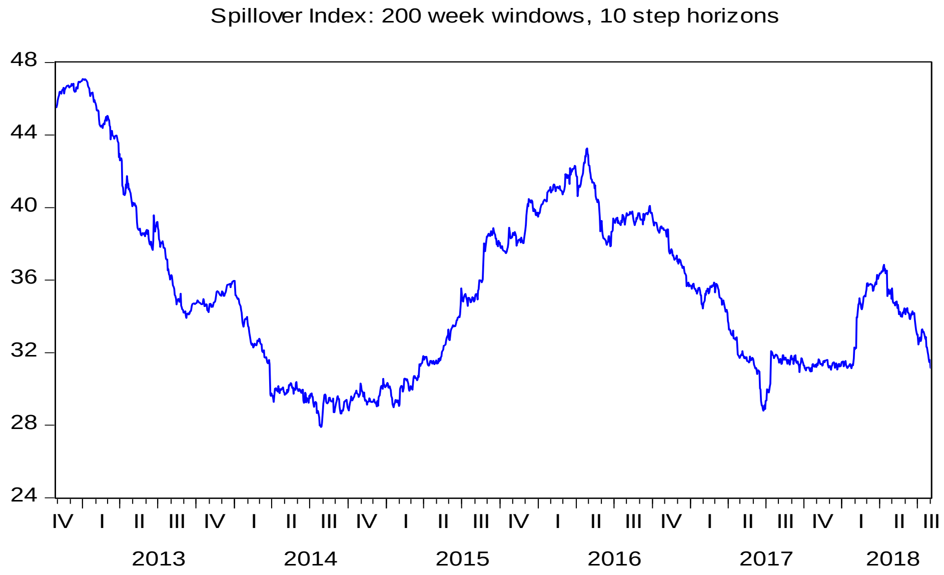
Importantly, the total returns spillover over the whole period is 26.2% (see Table 11b), this implies that 73.8% of the variation is due to specific (idiosyncratic) shocks. Although it implies that return spillover among the examined markets (housing, energy, agricultural commodities, and stock) is rather low, large own contribution measures of approximately over 95% is observed for REIT, WTI, renewables, and wheat.

Regarding directional spillover (expressed by equation 9 as 'to others' -'from others'), wheat has the highest (positive) net return spillover (43.9%) to others and orderly followed by REIT, WTI, S&P500, and renewable. It implies that the variables (which are components of the examined markets) are net transmitters of returns. Similarly, negative return spillover (net recipients) are experienced by NASDAQ, Brent, Sbeans, and Corn in highest-lowest order. This is obviously not without considering the individual directional from others. For instance, the S&P500 record the highest contribution (spillover) to the forecast error variance of the NASDAQ returns with about 60.8%. This is followed by the spillover of WTI to Brent with 36.6%, wheat to corn with 29.5%, REIT to S&P500 and NASDAQ with 26.2% and 18.9% respectively, corn to Sbeans with 15.0%, wheat to Sbeans with 13.6%. Also, corn (only agricultural commodity) record forecast error variance to renewable with 0.3%, but the commodities except corn record forecast error variance (although lower) to REIT, S&P500, and NASDAQ.

In a similar case, Table 11c presents the volatility spillovers over the entire sample period. The total volatility spillover over the estimated period is 22.9% so that 77.1% of the variation is due to idiosyncratic shocks. These values slightly differ from the returns spillovers earlier reported. And, the (net) directional risk spillovers 'from' and 'to' other market components are quite high and above the average of the directional return spillovers. It implies that lower magnitude of spillovers due to return may not translate to a lower magnitude of spillovers due to volatility (risk). The directional volatility spillover (expressed by equation 9 as ‘to others’ – ‘from others’), is highest in S&P500 (52.1%), and orderly followed by REIT (32.1%), wheat (26.1%), WTI (24.4%), corn (9.3%), and renewable (0.9%). And, the negative volatility spillover (net recipients) are experienced by NASDAQ (-87.8%), Sbeans (-36%), and Brent (-21.4%). However, on the basis of components’ risk spillovers, the NASDAQ seems to be more vulnerable to risk shocks of other markets (and component of other markets). This trend is empirically followed by Sbeans (37.7%), Brent (24.0%), S&P500 (22.6%), corn (21.4%), REIT (5.3%), WTI (2.4%), wheat (2.4%), and renewable (1.2%). For the pairwise directional spillover, higher degree of net spillover are observed among the agricultural commodities. In overall, the net spillover of the inter-market components are low (ranging from 0.0% to 0.8%). Importantly, although the total returns and volatility spillover indices are lower than 50% average, there exists some significant level of interdependence among the examined components. Also, giving the small value of volatility spillover index, it hints that the return volatility for the market components is determined by exogenous factors that are not examined in the VAR model.

5.4.2 Robustness Tests

Considering the return and volatility spillover indices estimates presented earlier (in Tables 11b & 11c), the rolling-sample analysis with 200-week (and 100) windows and 10 steps horizons are subsequently provided as Figure 9. In Figure 9, it presents the 200-week windows (a) and 100-week windows (b) for return spillover index. Although the dynamic outlook of the two windows present the same movement, it peak at about 50 in 2012 and downturn between 2017 and 2018 in 100-week windows for return spillover slightly differs from the 200-week windows. It implies that when more time is allowed, the return response would adjust as to avoid distress in the markets. Moreover, the return volatility spillover index for 200-week windows (see Figure 4) depict the existence of high volatility (period of high frequency immediately followed by period of low frequency) among the examined markets.



(a)

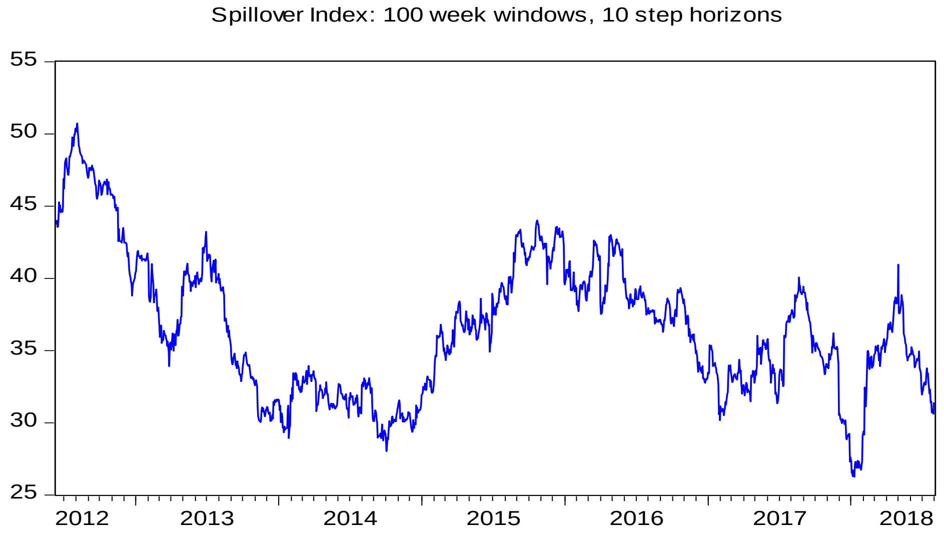


Figure 9: Returns Spillover Index for 200 (up) and 100 (down) Windows.

Also, a robustness investigation with a re-sampled data (in-sample) for the period January 01 2017- August 2, 2018 is employed to at least evaluate a new return spillover index (Tsai, 2015). The sample period is considered because of the obvious policy shifts in the US since the commencement of a new government on 20 January 2017. As evidently shown in Table 12, less of the variation is due to idiosyncratic shock in comparison with the return in the whole sample. Here, the total volatility spillover over the estimated re-sampled period is 30.5%. This implies that, although volatility spillover exists in the previous sample, the impact is explained in lower magnitude because of higher time lag.

Table 12: The Directional Returns Spillover (In-sample)

Variable	**1**	2	3	4	5	6	7	8	9	Contribution from others	Net spillover
1	**99.6**	0.0	0.0	0.0	0.1	0.0	0.2	0.0	0.0	0.4	53.4
2	33.9	**65.4**	0.1	0.0	0.4	0.0	0.0	0.2	0.0	34.6	-16.5
3	17.0	16.0	**66.2**	0.0	0.0	0.0	0.3	0.3	0.2	33.8	-30.4
4	0.2	0.2	0.2	**94.1**	3.1	0.5	0.4	0.0	1.3	5.9	10.4
5	0.8	0.8	0.7	2.0	**94.9**	0.0	0.7	0.0	0.0	5.1	35.6
6	0.3	0.5	0.1	1.9	33.4	**62.5**	0.1	1.0	0.2	37.5	-36.7
7	1.2	0.4	0.7	1.8	1.2	0.1	**94.2**	1.4	0.1	5.8	24.1
8	0.2	0.0	0.7	3.1	1.8	0.0	15.7	**78.3**	0.0	21.7	50.9
9	0.2	0.2	0.9	2.4	0.7	0.2	12.4	70.7	**12.4**	87.6	-85.8
Contribution to others	53.8	18.1	3.4	11.3	40.7	0.8	29.9	72.6	1.8	232.4	
Contribution to others	153.4	83.5	69.6	105.4	135.6	63.4	124.1	150.9	14.1	**Total** {**25.9%**}	

Note: Wheat=1, Corn=2, Sbeans=3, renewable=4, WTI=5, Brent=6, REIT=7, S&P 500=8, NASDAQ=9 Lag length selection by SIC (lag=1).

Also, the net contribution to others by REIT which is higher in the whole sample estimate is intensely higher (72.4%). In this sense, the finding corroborates the evidence that the housing market (in the United Kingdom) significantly determines the economic activity (Antonakakis & Floros, 2016). This is followed by wheat (39.6%), S&P500 (23.8%), and renewable (0.5%). Other variables, led by NASDAQ (followed by Sbeans, corn, Brent, and WTI) are net receiver of volatility spillovers. Importantly, the pairwise volatility spillover among the market components is more significant in this estimate. For instance, the values above and below the diagonal indices are more significant, especially the interdependence of the agricultural commodities and renewable with the components of other markets.

5.5 Concluding Remark

This investigation measures the magnitude of interdependence among the housing market, energy market and agricultural commodities in the US using the common components of the markets. Having employed the novelty of Diebold and Yilmaz (2012) over the daily period January 20, 2012-August 2, 2018, the findings revealed are characterized by the following empirical regularities. First, there is transmission of various types of shock among the housing market, energy market, stock market, and the agricultural commodities. Although slightly low, the inter-component market transmission (especially the volatility connectedness) is significant. There empirical evidence of the total returns and volatility spillover is significant. Second, over the whole sample period, the total volatility spillover is lower than the return spillover. Hence, it translates that higher return spillover would not naturally indicate higher volatility spillover. Nevertheless, the spillovers show large deviation over period of time which implies a period of high information spillovers. As such, the period is characterized by increased correlation between the examined markets vis-à-vis the market components (Tsai, 2015). Third, some of the market components are observed to exhibit different contribution pattern. For instance, among the energy components, Brent receives more returns and volatility contributions more than it gives while renewable and WTI gives more than it receives. This could be because the country's economy is energy-driven which is largely of WTI and renewable-related, while consuming less of Brent. Lastly, using a smaller sample-size (January 01, 2012-August 2, 2018), we found that there is relatively higher systemic risk currently existing among the examined markets.

The policymakers are expected to find the results of the current investigation very useful especially in the design of market framework of the United States. Importantly, part is the results from the robustness check which reveals higher total net volatility spillover where sample-size is limited to the time period of the current government of the United States. For instance, the relatively high net volatility contribution (spillover effect) from REIT to other markets should be a reminder of events preceding the GFC and its association with the United States' (US) sub-prime mortgage market. Hence, real estate and the housing market boom should be prevented in a precautionary approach. This could be done by increasing the resilience of other markets possibly through economic diversification programs.

Further study similar to the current one is essential to examining the relevancy of connectedness among market components especially for regional perspectives.

Chapter 6

CONCLUSION

While the GLOBIOM suggest the basis for the sustainability indicators, Evans et al. (2009) further identified land use, price of elasticity generation, greenhouse gas emissions, and social impacts among others as the sustainability indicators. In the process of investigating the interaction between the major land-based indicators, the first step of the study examines the land-oriented determinants of the renewable energy consumption. By using the Coastline Mediterranean Countries (CMC), simply for its high environmental activities land structure across the region, the study found that the use of agricultural land in the region is an important determinant of renewable energy consumption. Importantly, this observation is found to be significant in the long-run and in the short-run for some of the observed countries.

In a similar investigation, and considering that land resources as a major input in the construction and allocation of buildings and residential, the study found that carbon emission, housing policy, and real gross domestic product also determine the renewable energy consumption especially in the long-run. The results from the two studies affirms that GLOBIOM evidence of the land use activities (agricultural land and the housing construction and dwelling dynamics) are statistically significant. Also, the use of CMC as a case study is a contribution to the extant literature in addition to the empirical evidence of long-run relationship between the variables of concern (agricultural land and housing construction policy) and renewable energy consumption.

Subsequently, in chapter four, the study adopts the Markov-switch approach and found positive impacts of soybean and wheat on the renewable energy equity in two regimes. Sigificantly, the positive impact of soybean is an indication of a potential rise in the cost of renewable energy generation and its export. This impact is negative for corn in the both the stable and recession regimes. It suggests the reason corn has recently been preferred for food rather than a source of renewable energy in the US.

Conclusively, the last chapter details an investigation of the spillovers among the components of the housing market, energy market, and the agricultural commodities using the Diebold and Yilmaz (2012). Using the renewable equity, Crude oil WTI, Crude Brent, REIT, wheat, corn, and Soybeans, we found the return and volatility shock transmissions among these market (housing market, energy market, and the agricultural commodities) components. Also, among the market components, the total net volatility spillovers is higher than the total net returns, thus indicating that high/low volatility spillovers does not necessary translates to high/low returns spillover. Hence, in addition to examining the linkage between the environmental components of the GLOBIOM sustainability indicators, the current study further explores the financial market components, thus suggest underpinning the potential transmissions.

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APPENDICES

Appendix A: Market Interactions as a Multi-market Model

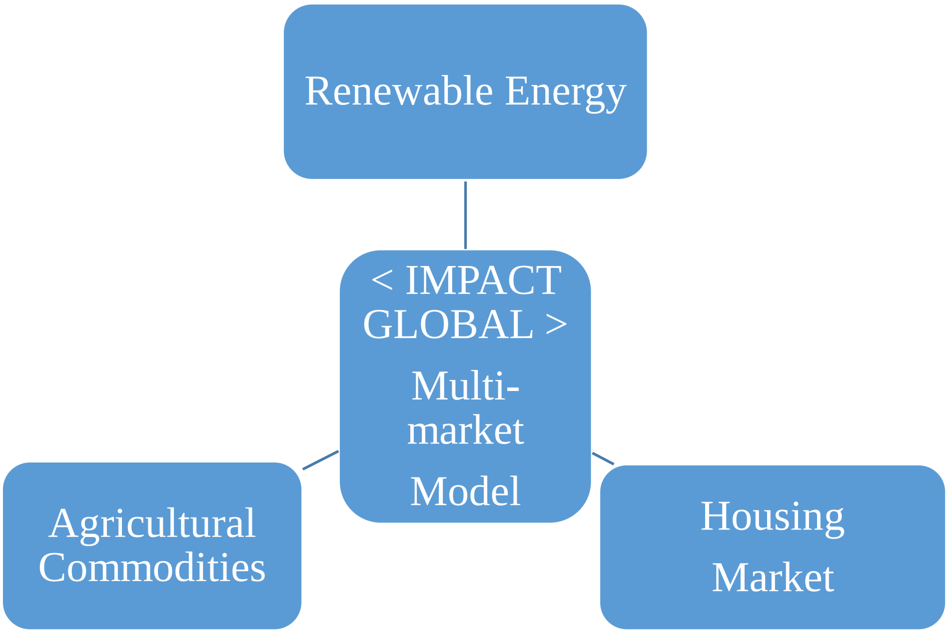

Figure A: Market Interactions in a Multi-market Model of IMPACT
Designed by author from Robinson et al (2015).

Appendix B: Statistical Distribution of the Variables across the Panel Countries

Table B: Proportions of RES and economic contributions of agriculture

Country	RES and Agricultural activities information as at 2016
Albania	% contribution of RES to total energy-mix is 38.69% (Hydro; > 5895 GWh,). % contribution of agriculture to economy is 22.9%.
Algeria	% contribution to RES to total energy-mix is 0.07% (Hydro; > 145 GWh, Solar; > 58 GWh, Wind; > 19 GWh) % contribution of agriculture to the economy is 13.3%.
B-H	% contribution of RES to total energy-mix is 41.75% (Hydro; > 5551 GWh) % contribution of agriculture to the economy is 7.7%.
Cyprus	% contribution of RES to total energy-mix is 9.39% (Solar; > 126, Wind; > 221). (% contribution of agriculture to the economy is 2.1%.
Egypt	% contribution of RES to total energy-mix is 6.41% (Hydro; > 13432, Solar; > 253, Wind; > 1345) % contribution of agriculture to the economy is 11.9%.
France	% contribution of RES to total energy-mix is 13.13% (Hydro; > 59400, Solar; > 7259, Tide, wave, ocean; > 487, Wind; > 21249) % contribution of agriculture to the economy is 1.6%.
Greece	% contribution of RES to total energy-mix 16.09% (Hydro; > 6150, Solar; > 3900, Wind; > 4621) % contribution of agriculture to the economy is 4.0%.
Israel	% contribution of RES to total energy-mix 9.34% (Hydro; > 24, Solar; > 1115, Wind; > 7) % contribution of agriculture to the economy is 1.3%.
Italy	% contribution of RES to total energy-mix 17.09% (Hydro; > 46970, Solar; > 22942, Wind; > 14844) % contribution of agriculture to the economy is 2.1%.
Lebanon	% contribution of RES to total energy-mix 3.20% (Hydro; > 479) % contribution of agriculture to the economy is 3.8%.
Malta	% contribution of RES to total energy-mix 3.95% (Solar; > 93)

	% contribution of agriculture to the economy is 1.4%.
Morocco	% contribution of RES to total energy-mix 11.78% (Hydro; > 2281, *Solar; > 6 GWh, Wind; > 2519) % contribution of agriculture to the economy is 13.6%.
Slovenia	% contribution of RES to total energy-mix 22.68% (Hydro; > 4091, Solar; > 274, Wind; > 6) % contribution of agriculture to the economy is 2.2%.
Spain	% contribution of RES to total energy-mix 17.35% (Hydro; > 31368, *Solar; > 13859, Wind; > 49325) % contribution of agriculture to the economy is 2.8%.
Tunisia	% contribution of RES to total energy-mix 12.92% (Hydro; > 69, Solar; > 41, Wind; > 448) % contribution of agriculture to the economy is 10.0%.
Turkey	% contribution of RES to total energy-mix 11.58% (Hydro; > 67146, Solar; > 194, Wind; > 11652) % contribution of agriculture to the economy is 7.0%.

Note: 50% of habitable land is used for agriculture comprising of 77% for livestock and 23% crops

Source: International Energy Agency (IEA) and World Development Indicator. Data was computed by the authors.

*Solar comprises of solar PV and thermal. B-H is Bosnia and Herzegovina.

Appendix C: Correlation Matrix

Table C: Result of cross-sectional dependence test and correlation

	rec	*gdp*	*cem*	*ald*
rec	1.000			
gdp	-0.388*	1.000		
cem	-0.271*	0.264*	1.000	
ald	0.271*	0.201*	0.0376	1.000

	rec	*gdp*	*drb*	CO_2
rec	1.000			
gdp	-0.145	1.000		
drb	0.285*	-0.059	1.000	
CO_2	-0.344*	0.275*	-0.142	1.000

Note: * denote a statistical significance at 1%.