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The Causal Links between Economic Growth, Renewable Energy, Financial Development and Foreign Trade in Gulf Cooperation Council Countries

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ABSTRACT

This paper examines the causal relationship between renewable energy consumption, real gross domestic product, trade and financial development (FD) for the Gulf Cooperation Council (GCC) countries during the period 1980-2012. Compared to the previous studies, our models are extended by including the FD as macroeconomic factor. The results indicate bidirectional causality in both short and long-run between output and exports. While, there is no evidence of causality in the short-run between output and renewable energy consumption or private sector credit and between exports and renewable energy consumption or private sector credit. Moreover, the long-run estimated results indicate that there is evidence of a statistically significant impact of renewable energy consumption, exports and private sector credit on output. Our finding indicates that renewable energy use and exports are able to increase the economic growth for the GCC countries. Nevertheless, we find negative impact of the FD on economic growth related to the deflationary monetary policy of the considered countries.

Keywords: Granger Causality, Panel Cointegration, Renewable Energy Consumption, Economic Growth, Financial Development, Trade, Gulf Cooperation Council Countries

JEL Classifications: C33, O24, Q43

1. INTRODUCTION

Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates make up the Gulf Cooperation Council (GCC) and also are considered the largest producers of oil and natural gas in the Arab world. According to the Reich's studies (2010), these countries are ranked among the 25 countries that emit carbon dioxide (CO_2) per capita. Several studies have shown that is advantageous for these countries to transform oil wealth into a means of financing for the creation of renewable energy. That is why these countries have begun a process in infrastructure and investment in energy. In addition, the Gulf countries have become aware of the lessons taken by Western countries as well on the seriousness of energetic crisis and its impact on the intensive use of exhaustible natural resources to promote economic growth as on their neglect of environmental factor. Pursuant to reports from the Bloomberg New Energy Finance, the increasing cost of fossil fuels and the national economic policies to promote investment and therefore reduce unemployment rate have motivated the increase of the global investment in renewable energy during last decade.

This motivation is the basis of much recent studies that analyze the causal relationship between renewable energy consumption and economic growth. Empirical results of these studies are based on panel data or individual time series. In this regard, we can refer to the studies of Apergis and Payne (2010a; 2010b; 2011; 2012) and Sadorsky (2009b). Also, Sadorsky (2009a) has analyzed the causal relationship between economic growth, renewable energy consumption and CO_2 emissions. According to Doukas et al. (2006), "CO_2 emissions per capita, energy intensities and CO_2 emissions per gross domestic product (GDP) in the GCC countries are higher than the average of 25-EU and the average of the OECD countries." The causal relationship between economic growth, renewable energy and trade is the subject of several studies e.g., Sadorsky (2012) and Ben Aïssa et al. (2014). The common denominator of this literature is related to variations analysis in renewable energy consumption, trade openness and the contribution of the capital and labor and their impact on the GDP change. Besides these factors that may play a crucial role in economic growth, contemporary research proves energy use and productivity are affected by the financial development (FD) (e.g., Shahbaz and Lean, 2012; Shahbaz et al., 2013).

To our knowledge, the interaction between renewable energy consumption and economic growth including FD has not been beforehand analyzed. It is therefore the task of the present paper which examines a panel of GCC countries. In this paper we investigate the relationship between energy consumption and economic growth by incorporating FD and exports as important factors of production function.

This paper is structured as follows. Section 2 briefly reviews of previous empirical works on the relationship between energy consumption, trade, FD and economic growth. Section 3 describes the econometric methods to be used in our empirical issue. Section 4 presents the used data and summary statistics. Section 5 discusses the obtained results. Section 6 focuses to analyze the short and long-run causality. Section 7 provides concluding remarks and discussions.

2. LITERATURE REVIEW

During the last three decades, the importance of energy has been valued through industrialization. Therefore, we are witnessing a wave of development and emergence of economies that have experienced rapid increase in trade, income and energy consumption. Nevertheless, Stern and Cleveland (2004) divided the neoclassical economic growth models into three categories. The first indicates that technological variations are the most important factors influencing economic growth and the production function. At first, economy reaches an equilibrium level. Then this improvement of the technology develops economic growth rather than capital.

The second category involves that the use of natural capital is a determinant for a stable economic growth. Whereas, the third thought considers the change in technology and natural resources for the determination of economic growth. Therefore, with human and natural capital and improved technology we can reach stable growth. It should be noted that these models indicated that share of energy for economic activity was seen in the proportion of the cost. In another way, these models considered energy as an intermediate good and not an input for the production.

For Turkish economy, Saatci and Dumrul (2013) highlighted empirically the role of energy consumption in economic growth. Moreover, Bhattacharya et al. (2016) confirm the evidence of long-run dynamic between economic growth and energy consumption in their empirical framework from top 38 countries. Also, Stern (2000), Lee and Chang (2008), and Apergis and Danuletiu (2014) emphasized that energy consumption plays an important role in economic growth. It is the complement of labor and capital in the production function. From their empirical study based on the relationship between natural gas consumption and economic growth, Ozturk and Al-Mulali (2015) considered trade openness, total labor force and gross fixed capital formation as major determinants of GDP growth. Costantini and Martini (2010) noted that energy consumption is itself a function of energy prices i.e., the energy consumption itself in another function depends on economic output, because it is the increase in production that attracts energy. In this case, there is a relationship between reaction energy consumption and the market size. Currently, the GDP for each country is very important because it shows the market size and the purchasing power of people. If there is a significant relationship between market size and consumption of renewable energy, countries can apply and develop the use of this energy.

Apergis and Payne (2010a; 2010b; 2011; 2012) and Sadorsky (2009b) analyze empirically the causal relationship between economic growth and the consumption of renewable energy. They use GDP, capital, labor and renewable energy use to show that in EURASIA there is a bidirectional relationship between economic growth and renewable energy consumption. They showed the same result for the OECD countries in 2010. The same result was shown by Sadorsky (2009a), Menyah and Wolde-Rufeal (2010), Menegaki (2011), and Leitao (2014) in their empirical studies on the causal relationship between economic growth, renewable energy consumption and CO_2 emissions. Furthermore, Tang et al. (2016) confirm that energy consumption, foreign direct investment (FDI) and capital stock affect positively the economic growth in Vietnam. For more precision, the empirical findings of Tugcu et al. (2012) revealed in the long-run that either renewable or non-renewable energy consumption issues contributed to more explain economic growth and augmented production function is more effective on explaining the considered relationship.

Thus, we are now witnessing at large published research investigating the causal relationship between energy consumption and economic growth and a very little known about the causal relationship between energy consumption, economic growth and trade. Indeed, trade openness constitutes a factor to be introduced in the production function in order to explain the GDP variations.

On a panel of six MENA countries, Narayan and Smyth (2009) showed a short-run Granger causality running from electricity consumption to GDP and from income to exports. Lean and Smyth (2010a) by Granger causality tests show the existence of unidirectional causality running from economic growth to electricity generation. Using panel cointegration techniques, Sadorsky (2011) indicates the meaning that trade can affect energy consumption for eight MENA countries. On a panel of seven South American countries, Sadorsky (2012) proves a long-run relationship between trade and energy consumption. Also in the same econometric framework, Ben Aïssa et al. (2014) analyze the relationship between renewable energy consumption, trade and output for 11 African countries. From panel error correction model (ECM), their results exhibit bidirectional causality between output and exports and between output and imports in both the short and long-run. Also, their estimations show in the long-run that renewable energy consumption and trade have a statistically significant and positive effect on output. Menegaki and Ozturk (2016) investigated an empirical study on the causal relationship between economic growth and renewable energy for seven MENA countries. In the long-run, their results showed that renewable energy affected negatively GDP growth.

All this literature shows that changes in renewable energy consumption and trade openness affect the GDP variations. However, capital, labor, renewable energy, exports and imports are not the only factors explaining economic growth. Indeed, the financial system can promote growth. In fact, financial systems facilitate the trading, hedging, diversifying and pooling of risk; they allocate resources, monitor managers and exert corporate control, mobilize savings and ease the exchange of goods and services (Levine, 1997). Thus it is commonly known that FD encompasses raises in the flow of FDI, dynamism in stock market and banking sectors, legal environment conducive and domestic credit to private sector. Therefore, well-functioning financial markets can positively contribute to economic growth. Additionally, recent empirical studies reveal positive causal relationship between FD and economic growth. Salahuddin et al. (2015) showed that electricity consumption and economic growth stimulate CO_2 emissions in GCC countries while FD reduces it. Also findings of Ben Jebli and Ben Youssef (2017) indicated that an increase in agricultural value added reduces CO_2 emissions in North Africa countries. Using fully modified ordinary least square (FMOLS), Ozturk and Al-Mulali (2015) revealed that economic growth, urbanization and FD increase CO_2 emissions in Europe. According to Xu (2000) and Bell and Rousseau (2001) the causality from FD supports finance-led growth by increasing efficiency. Then a policy improving FD may be a catalyst for saving, borrowing and investment. Sadorsky (2011) highlighted that consumers envisage purchasing consumer durables which add to energy demand with low borrowing cost. Sadorsky (2010) analyzed 22 emerging economies for the period from 1990 to 2006 using different FD indicators. He argued a small and positive effect on economic growth. Islam et al. (2013) indicated that FD allows for more investment in energy equipments which lowers energy use. They found a causal relationship from FD to energy consumption in Malaysia case. By incorporating FD and trade openness as determinants of economic growth in case of Pakistan, Shahbaz (2012) argued by applying cointegration and causality approaches that last determinants promote economic growth. For five South Asian countries, Nasreen et al. (2017) showed that financial stability improves environmental quality. However, in the long-run the increase in economic growth, energy consumption and population density are detrimental for environment quality. Using structural break unit root tests, autoregressive distributed lag (ARDL) bounds test approach to cointegration and the Johansen cointegration test, Rafindadi and Ozturk (2016) investigated for the Japanese economy the relationship between economic growth and electricity consumption by introducing FD, capital, and trade openness in an extended Gobb-Douglas production function. In the long-run, their findings showed that a rise in FD, economic growth, exports and imports will exert a significant pressure on the Japanese electricity consumption. Using an ARDL approach to demonstrate the existence of environmental Kuznets curve theory in the Austria economy, Benavides et al. (2017) analyzed both short and long-run relationships between methane emissions, economic growth, electricity production from renewable sources and trade openness.

In this context, we note that the aim of this research is not to determine the source of funding for private sector or the role of banking sector for private sector funding and thereafter for the economic growth but to examine the causal effect between FD and economic growth.

3. ECONOMETRIC FRAMEWORK

Over the past three decades, it is well known that there is rapid increasing in output, trade and energy consumption in both emerging and developing countries (Sadorsky, 2011). It is a well interesting to find out more about the dynamic relationship between these variables. We think that since the study by Al-Iriani (2006) which investigated the causality relationship between GDP and energy consumption in the six countries of GCC, there are no studies which are incorporated in the same frame. Nonetheless, Lean and Smyth (2010a; 2010b), Sadorsky (2012) and Ben Aïssa et al. (2014) studied the relationship between economic growth, energy consumption and trade through the production function on a different set of countries other than that of GCC.

Furthermore, according to our knowledge, there is no empirical research in GCC countries trying to investigate the causal links between economic growth and renewable energy consumption and in addition that introduce foreign trade and FD as separate factors of production. In this paper, the last production's function factor is approximated by the domestic credit to private sector. However, according to Sadorsky (2011), trade openness can be measured using either exports or imports. Moreover, several empirical studies have used imports, exports and net exports each separately variables reflect the impact of trade openness on economic growth.

Despite the possibility for using net exports in this research, we believe that the imports do not reflect the reality of economic activity due to the high level of GDP for the GCC countries and thus the huge capacity to import regardless of economic growth level. Thus we use exports in this research because we think that there is a growth-led export in GCC countries, since a positive variation implies necessarily a positive change in production level and therefore a wider use of production factors.

According to Sadorsky (2012) and Ben Aïssa et al. (2014) studies, we use the same specification model that trying to study the relationship between real GDP, capital stock (K), labor force (L), renewable energy consumption (RE), real exports (RX) and proxy of financial development (FD), then it can be written as the following form:

$$GDP_{it} = f(K_{it}, L_{it}, RE_{it}, RX_{it}, FD_{it}) \quad (1)$$

By using the natural logarithmic transformation on Equation 1, we obtain the following specification:

$$gdp_{it} = \alpha_i + \delta_i t + \beta_{1i} k_{it} + \beta_{2i} l_{it} + \beta_{3i} re_{it} + \beta_{4i} rx_{it} + \beta_{5i} fd_{it} + \varepsilon_{it} \quad (2)$$

In Equation 2, countries and time period are denoted respectively by the subscript i (i = 1,…N) and t (t = 1,…T). Where, α_i, δ_i

and ε translate respectively individual fixed country effects, deterministic trends and stochastic error term.

To meet goals fixed in this paper, we use panel unit root tests, panel cointegration approach, multivariate granger causality and ECM in the empirical analysis on the set of GCC countries composed by Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates.

It is commonly known that is more interesting to use panel estimation techniques for estimating the long-run elasticities from Equation 2, because these techniques based on cross-sections of time series provide more degrees of freedom and efficiency than those based on individual time series. When the time series dimension of each cross-section is short, panel cointegration techniques are particularly useful.

During last decade panel cointegration techniques have been used in most studies analyzing the long-run relationship between energy consumption and output (e.g. Lee, 2005; Al-Iriani, 2006; Narayan and Smyth, 2008; Lee and Chang, 2008; Lee et al., 2008; Apergis and Payne, 2009a; 2009b; Sadorsky, 2009a; 2009b; 2011; 2012; Shahbaz et al., 2013; Ben Aïssa et al., 2014). According to these empirical frameworks, we begin our empirical framework by analyzing data and descriptive statistics in the following section.

4. DATA AND SUMMARY STATISTICS

We adopt the approach used by Ben Aïssa et al. (2014), Lean and Smyth (2010a; 2010b) and Sadorsky (2012). We produce a balanced panel on six GCC countries. The data set used in the empirical framework is annual frequency over the period 1980-2012 and taken from the World Bank (2013) and World Development Indicators data base. The set of the variables that are used comprises output resumes real GDP. Capital stock (*K*) is measured by the gross fixed capital formation. The two last variables are measured in billion of constant 2005 US dollars. The total number of labor force constitutes labor (*L*) is measured in millions. Renewable energy consumption (*RE*) specified as total renewable electricity consumption (hydroelectric and non-hydroelectric renewable) is measured in billion of kilowatt hours. Real exports (*RX*) are obtained through the value of merchandise exports measured in million of current US dollars and deflated by the price level of consumption. Four our study, the proxy of FD to indicate the FD indicator is obtained from private sector credit divided by the nominal GDP.

The descriptive statistics for each variable (real GDP, capital stock, labor force, renewable energy consumption, real exports and proxy of FD) are summarized in Table 1 and the resulting series denoted as *GDP*, *K*, *L*, *RE*, *RX* and *FD*.

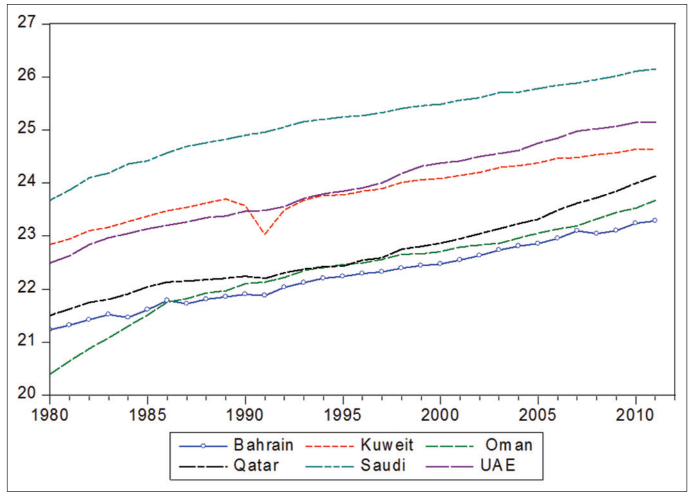
The log-level of the renewable energy consumption, the real GDP, the exports and the domestic credit to private sector are plotted in Figures 1-4 respectively. From figures, we observe that there is common trending behavior, which may be indicative for some relationship between variables. Overall, all variables have been increasing across time for each of the GCC countries.

Table 1: Descriptive statistics

Variables	Mean±SD	Maximum	Minimum
GDP	74.477±105.572	669.507	3.741
K	7.260±35.300	265.000	0.0004
L	1.723±2.243	9.800	0.107
RE	0.031±0.044	0.227	0.0007
RX	40.045±82.337	515.873	0.513
FD	38.723±17.659	93.546	6.815

SD: Standard deviation, GDP: Gross domestic product, RE: Renewable energy consumption, RX: Real exports, FD: Financial development

Figure 1: Renewable energy consumption



Furthermore, the figures show that Saudi Arabia (Bahrain) has the highest (lowest) renewable energy consumption, real GDP and exports, while the highest (lowest) domestic credit to private sector are observed in Kuwait (Saudi Arabia). Otherwise, figures show a dramatic decline in the real GDP, real exports and domestic credit to private sector early 90's (the 1991 Kuwait war) and the late 2010 (the global financial crisis of 2007-2008) for all GCC countries[1], while there is no significant change in renewable energy consumption.

In the following section, we undertake our empirical study by analyzing firstly stationarity of variables. Secondly, we carry out the panel unit root tests for cointegration. Thirdly, we proceed by testing causality using Engle and Granger (1987) to estimate an ECM. Fourthly, we finish our empirical framework by estimating the long-run elasticities issued from Equation 2.

5. EMPIRICAL RESULTS

5.1. Unit Root Tests

To analyze the stationarity of variables, we proceed by computing five panel unit root tests. Breitung (2000) and Levin et al. (2002) assumed that there is a common unit root process across the cross-sections i.e., homogeneity of the autoregressive root. For these tests, the null hypothesis indicates that each time series contains

1 Unlike Sadorsky (2012), in the present paper we do no attempt to include structural breaks in the estimated model and the panel cointegration tests. Sadorsky (2012) investigates the causal links between energy consumption, output and trade by including dummy variables related to many economic and political events.

Figure 2: Real gross domestic product

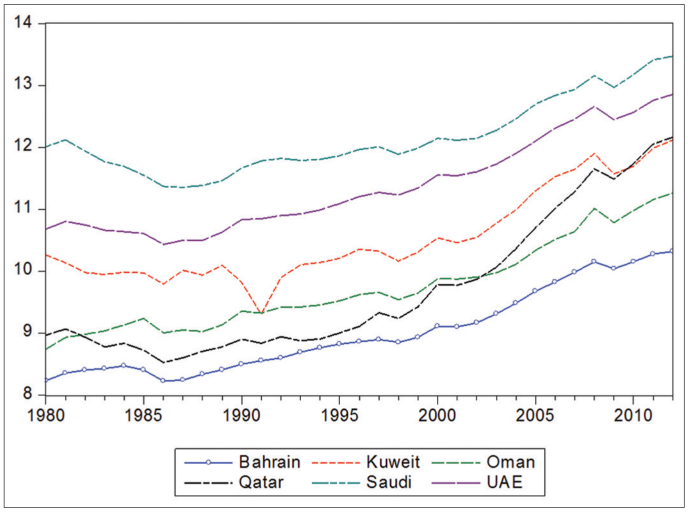


Figure 3: Exports

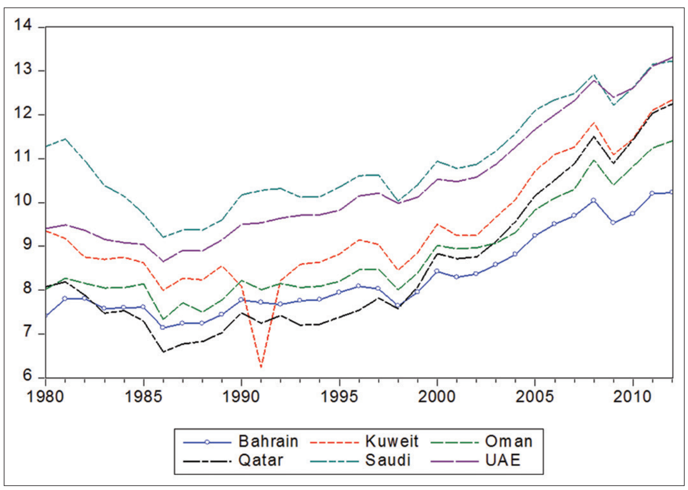
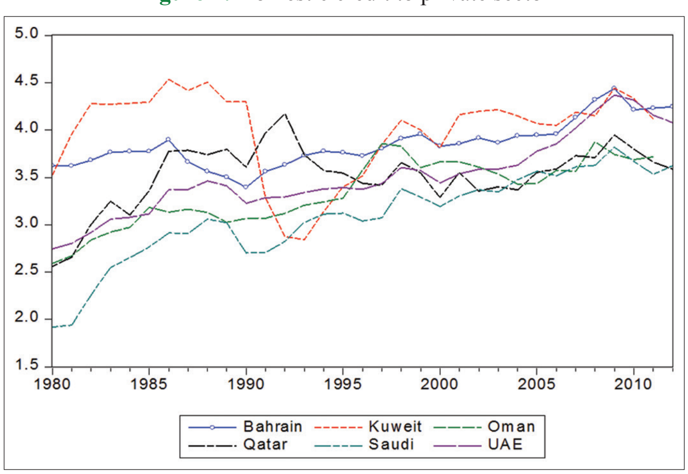


Figure 4: Domestic credit to private sector



a unit root while the alternative hypothesis signifies that each time series is stationary. Nevertheless, by relaxing the restrictive assumption of the two first tests, Maddala and Wu (1999) proposed a Fisher-type test (Fisher - augmented Dickey-Fuller [ADF] and Fisher-PP) and Im et al. (2003) supposed that there is an individual unit root process across the cross-sections i.e., heterogeneity of the autoregressive root. For these tests the null hypothesis is that there is a unit root while the alternative hypothesis allows some (but not all) of the individual to have unit roots.

According to results summarized in Table 2, the unit root tests indicate that the null hypothesis of unit root cannot be rejected for each series in levels, while this hypothesis can be rejected for each series in first differences at 1% significance level.

5.2. Cointegration Analysis

From the results raised in Table 2 and obtained from checking unit root tests for all variables which are stationary in first differences, panel cointegration approaches must be realized. Panel cointegration is checked using Pedroni (1999; 2004) and Kao (1999) tests. Pedroni cointegration approach is based on the residuals from Equation 2 to test unit root in the following specification:

$$\varepsilon_{it} = \rho_i \varepsilon_{i,t-1} + \nu_{it} \quad (3)$$

In order to test the null hypothesis of no cointegration in heterogeneous panels, Pedroni (1999; 2004) computes seven statistics summarized in two categories of cointegration tests. The forth first statistics are included in the first category that indicates within-dimension (panel statistics). In this case, the first order autoregressive term is assumed to be the same across all the cross-sections. While the last three statistics compose the second category is appointed between-dimension (group tests). In this case, the autoregressive parameter is allowed to vary over the cross-sections. Following the first category, statistics are computed whilst considering a common value of ρ for all i. The null hypothesis of no cointegration suppose $\rho_i = 1$ for all i versus an alternative cointegration hypothesis based on $\rho_i = \rho < 1$ for all i. Within-dimension is more restrictive than between-dimension. The last one allows for heterogeneity of the parameters across countries. The null hypothesis of no cointegration suppose $\rho_i = 1$ for all i versus an alternative cointegration hypothesis based on $\rho_i < 1$ for all i.

Following results allowed from Table 3, PP-statistic and ADF-statistic either in within-dimension or in between-dimension show the existence of cointegration at 1% significance level. Finally we conclude whilst considering these four statistics that there is a long-run relationship between variables.

In this paper, we investigate more in the cointegration analysis by using Kao cointegration test proposed by Kao (1999) for testing panel cointegration. Results issued from this test are summarized in Table 4, that indicate the reject at 1% significance level of the null hypothesis which reports no cointegration. According to Kao test we confirm thereby the existence of cointegration that allows a long-run relationship between variables.

6. SHORT AND LONG-RUN ANALYSIS

6.1. Short and Long-run Causality

The checking of cointegration is founded, then the approach of Engle and Granger (1987) can be used to estimate an ECM which

Table 2: Panel unit root tests

Variables	Unit root tests for series in levels					Unit root tests for series in first differences				
	LLC	Breitung	IPS	F-ADF	F-PP	LLC	Breitung	IPS	F-ADF	F-PP
gdp	5.179	3.353	0.609	0.042	0.009	−2.810	−7.510	−6.844	72.014	147.831
P	1.000	0.999	0.729	1.000	1.000	0.006***	0.000***	0.000***	0.000***	0.000***
K	4.741	4.931	3.198	10.540	1.559	−7.694	−1.522	−3.384	45.939	78.632
P	1.000	1.000	0.999	0.568	0.999	0.000***	0.006	0.000***	0.000***	0.000***
L	1.130	−0.001	8.374	11.726	0.002	−1.865	−1.596	−2.842	29.851	48.303
P	0.870	0.499	1.000	0.468	1.000	0.003***	0.002	0.005***	0.002***	0.003***
re	9.562	5.291	11.419	0.011	0.000	−4.819	−2.294	−2.918	19.446	38.508
P	1.000	1.000	1.000	1.000	1.000	0.000***	0.000	0.002***	0.007***	0.000***
rx	6.969	7.942	8.657	0.045	0.002	−8.105	−8.632	−9.145	76.777	131.914
P	1.000	1.000	1.000	1.000	1.000	0.000***	0.000	0.000***	0.000***	0.000***
fd	1.122	−0.666	11.595	2.975	1.973	−9.502	−4.643	−5.915	97.332	121.107
P	0.869	0.252	1.000	0.995	0.999	0.000***	0.000	0.000***	0.000***	0.000***

F-ADF and F-PP indicate respectively Fisher-ADF and Fisher-PP, All unit root tests were run with a constant and deterministic time trend, ***Critical values at the 1% significance level. ADF: Augmented Dickey-Fuller, PP: Phillips–Perron, LLC: Levin, Lin and Chu, IPS: Im, Pesaran, Shin, GDP: Gross domestic product, RE: Renewable energy consumption, RX: Real exports, FD: Financial development

Table 3: Pedroni co-integration tests

Alternative hypothesis: Common AR coefficients (within-dimension)				
Tests	Statistic	P	Weighted statistic	P
Panel *v*-statistic	0.961	0.168	0.599	0.274
Panel ρ-statistic	1.158	0.876	0.956	0.830
Panel PP-statistic	−2.663	0.004***	−2.931	0.002***
Panel ADF-statistic	−2.669	0.004***	−3.097	0.001***
Alternative hypothesis: Individual AR coefficients (between-dimension)				
	Statistic	P		
Group ρ-statistic	1.854	0.968		
Group PP-statistic	−3.461	0.001***		
Group ADF-statistic	−2.795	0.003***		

Null hypothesis: No cointegration. Trend assumptions: Deterministic intercept and trend. Lag selection: Automatic SIC with a maximum lag of 5. ***Critical values at the 1% significance level, SIC: Schwarz information criterion, ADF: Augmented Dickey-Fuller, PP: Phillips–Perron, AR: Autoregression

Table 4: Kao cointegration test

Tests	t-statistic	P
ADF	−3.881	0.001***
Residual variance	0.0014	
HAC variance	0.0013	

Null hypothesis: No cointegration. Trend assumption: No deterministic trend. Automatic lag selection based on SIC with max lag of 5. ***Critical value at the 1% significance level. ADF: Augmented Dickey-Fuller, SIC: Schwarz information criterion, HAC: Heteroskedasticity and autocorrelation consistent

exhibits short and long-run relationship between variables. Short-run dynamic and long-run dynamic can be investigated from the vector ECM for Equation 2 as follows:

$$\Delta gdp_{it} = \lambda_{1i} + \sum_{j=1}^{q}\lambda_{1,1ij}\Delta gdp_{it-j} + \sum_{j=1}^{q}\lambda_{1,2ij}\Delta k_{it-j} + \sum_{j=1}^{q}\lambda_{1,3ij}\Delta l_{it-j} + \sum_{j=1}^{q}\lambda_{1,4ij}\Delta re_{it-j} + \sum_{j=1}^{q}\lambda_{1,5ij}\Delta rx_{it-j} + \sum_{j=1}^{q}\lambda_{1,6ij}\Delta fd_{it-j} + \gamma_{1i}\varepsilon_{it-1} + \omega_{1it} \quad (4a)$$

$$\Delta k_{it} = \lambda_{2i} + \sum_{j=1}^{q}\lambda_{2,1ij}\Delta gdp_{it-j} + \sum_{j=1}^{q}\lambda_{2,2ij}\Delta k_{it-j} + \sum_{j=1}^{q}\lambda_{2,3ij}\Delta l_{it-j} + \sum_{j=1}^{q}\lambda_{2,4ij}\Delta re_{it-j} + \sum_{j=1}^{q}\lambda_{2,5ij}\Delta rx_{it-j} + \sum_{j=1}^{q}\lambda_{2,6ij}\Delta fd_{it-j} + \gamma_{2i}\varepsilon_{it-1} + \omega_{2it} \quad (4b)$$

$$\Delta l_{it} = \lambda_{3i} + \sum_{j=1}^{q}\lambda_{3,1ij}\Delta gdp_{it-j} + \sum_{j=1}^{q}\lambda_{3,2ij}\Delta k_{it-j} + \sum_{j=1}^{q}\lambda_{3,3ij}\Delta l_{it-j} + \sum_{j=1}^{q}\lambda_{3,4ij}\Delta re_{it-j}\Delta l_{it} + \sum_{j=1}^{q}\lambda_{3,5ij}\Delta rx_{it-j} + \sum_{j=1}^{q}\lambda_{3,6ij}\Delta fd_{it-j} + \gamma_{3i}\varepsilon_{it-1} + \omega_{3it} \quad (4c)$$

$$\Delta re_{it} = \lambda_{4i} + \sum_{j=1}^{q}\lambda_{4,1ij}\Delta gdp_{it-j} + \sum_{j=1}^{q}\lambda_{4,2ij}\Delta k_{it-j} + \sum_{j=1}^{q}\lambda_{4,3ij}\Delta l_{it-j} + \sum_{j=1}^{q}\lambda_{4,4ij}\Delta re_{it-j} + \sum_{j=1}^{q}\lambda_{4,5ij}\Delta rx_{it-j} + \sum_{j=1}^{q}\lambda_{4,6ij}\Delta fd_{it-j} + \gamma_{4i}\varepsilon_{it-1} + \omega_{4it} \quad (4d)$$

$$\Delta rx_{it} = \lambda_{5i} + \sum_{j=1}^{q}\lambda_{5,1ij}\Delta gdp_{it-j} + \sum_{j=1}^{q}\lambda_{5,2ij}\Delta k_{it-j} + \sum_{j=1}^{q}\lambda_{5,3ij}\Delta l_{it-j} + \sum_{j=1}^{q}\lambda_{5,4ij}\Delta re_{it-j} + \sum_{j=1}^{q}\lambda_{5,5ij}\Delta rx_{it-j} + \sum_{j=1}^{q}\lambda_{5,6ij}\Delta fd_{it-j} + \gamma_{5i}\varepsilon_{it-1} + \omega_{5it} \quad (4e)$$

$$\Delta fd_{it} = \lambda_{6i} + \sum_{j=1}^{q}\lambda_{6,1ij}\Delta gdp_{it-j} + \sum_{j=1}^{q}\lambda_{6,2ij}\Delta k_{it-j} + \sum_{j=1}^{q}\lambda_{6,3ij}\Delta l_{it-j} + \sum_{j=1}^{q}\lambda_{6,4ij}\Delta re_{it-j} + \sum_{j=1}^{q}\lambda_{6,5ij}\Delta rx_{it-j} + \sum_{j=1}^{q}\lambda_{6,6ij}\Delta fd_{it-j} + \gamma_{6i}\varepsilon_{it-1} + \omega_{6it} \quad (4f)$$

$$\varepsilon_{it} = gdp_{it} - \hat{\beta}_{1i}k_{it} - \hat{\beta}_{2i}l_{it} - \hat{\beta}_{3i}re_{it} - \hat{\beta}_{4i}rx_{it} - \hat{\beta}_{5i}fd_{it} \quad (4g)$$

Where, Δ the first difference operator, *q* is the lag length that is determined and specified automatically by the Schwarz information criterion, *gdp* is the natural log of real GDP, *k* is the natural log of capital stock, *l* is the natural log of labor force, *re* is the natural log of renewable energy consumption, *rx* is the natural log of real exports, *fd* is the natural log of proxy of FD measured by private sector credit and ε is the error correction term (ECT) denoted in Table 5 by ECT which the residuals obtained from Equation 2 that represents the long-run relationship and ω is a random error term. The results from testing Granger causality between variables which determine the relation described by Equation 2 are reported in Table 5. The Granger-causality procedure like as developed by Engle and Granger (1987) is performed in two steps. The first step is conducted by using OLS estimation method on Equation 2 which residuals must be retrieved. The second step is carried out through the estimations of Equation 4a to Equation 4f. For the short-run dynamics significance is tested by using Granger-causality F-statistic, while t-statistics are used to test significance of the ECT.

For the short-run Granger-causality, results summarized in Table 5 show that there is a bidirectional causality between output and exports and between renewable energy and labor. Therefore, there is evidence of Granger-causality running from exports to output at the 1% significance level. The same evidence running from output to exports is looked at 5% significance level. These two results confirm those obtained by Sadorsky (2011a; 2011b; 2012) and Ben Aïssa et al. (2014). Also, there is evidence of Granger-causality running from renewable energy consumption to labor at the 5% significance level. The same evidence is noticed from labor to renewable energy consumption at the 1% significance level. These results are not approved by Ben Aïssa et al. (2014). Nevertheless, we find unidirectional causality running from output and exports to capital at 5% significance level and 1% significance level, respectively.

For pairs of the following variables (*gpd*, *l*), (*gdp*, *re*), (*gdp*, *fd*), (*k*, *l*), (*k*, *re*), (*l*, *ex*), (*re*, *rx*), (*k*, *fd*), (*l*, *fd*), (*re*, *fd*) and (*rx*, *fd*), we show that there is no short-run causality. The same results are obtained by Ben Aïssa et al. (2014).

For the long-run causality, we find that the ECT is statistically significant for output and exports equations at the 10% significance level, and for private sector credit (*fd*) equation at the 5% significance level. Then, three assertions can be highlighted. Firstly, there is a long-run causality from capital, labor, renewable energy consumption, exports and private sector credit to output. Secondly, there is a long-run causality from output, capital, labor, renewable energy consumption and private sector credit to exports. Thirdly, there is a long-run causality from output, capital, labor, renewable energy consumption and exports to private sector credit.

Under similarity between our results and those found by Sadorsky (2011a; 2011b; 2012) and Ben Aïssa et al. (2014), the both bidirectional short-run causality and long-run causality between output and exports indicate a feedback impact between economic growth and exports. It means that exports reduction or conservation policies will reduce economic growth. Thus, the GCC countries authorities must implement incentive policies in order to further promote exports.

6.2. Long-run Elasticities Estimates

The long-run elasticities estimated from Equation 2 can be obtained using the OLS, nevertheless these estimators will be asymptotically biased within the framework as panel estimation. Furthermore, their distribution depends upon nuisance parameters. This is why the long-run estimates for Equation 2 are conducted using the FMOLS and the dynamic OLS (DOLS) according to Pedroni (2001; 2004) approaches. These procedures generate consistent estimates of the relevant panel variables in the cointegrated production function. Also, these techniques control for potential endogeneity of the regressors and serial correlation. To correct endogeneity and serial correlation, FMOLS and DOLS use non-parametric and parametric approaches, respectively. Therefore, it is unnecessary to use ordinary last squares for estimating long-run elasticities. These later are the estimators from the long-run cointegration relationship since the variables used in Equation 2 are measured in natural logarithms. In order to take into consideration of the heterogeneity impact, we calculate long-run elasticities assuming that regression coefficients change across cross sections i.e., between-dimension estimators.

The outcomes available in Table 6 show that there are similar results issued from FMOLS and DOLS approaches in terms of sign, magnitude and statistical significance for each variable. From this table, the estimated coefficients from the long-run cointegration relationship can interpreted as long-run elasticities. For each approach, the estimated coefficient for each of the following variables capital, labor, renewable energy consumption and exports is positive and statistically significant at 1% level

Table 5: Short and long-run Granger-causality tests

Causality direction	Short-run						Long-run
	Δ*gdp*	Δ*k*	Δ*l*	Δ*re*	Δ*rx*	Δ*fd*	ECT
Causality from							
Δ*gdp*	-	4.18 (0.04)**	0.02 (0.87)	1.07 (0.30)	5.68 (0.01)**	0.22 (0.63)	−0.26 [0.09]*
Δ*k*	0.48 (0.48)	-	1.10 (0.29)	0.35 (0.55)	0.69 (0.40)	0.68 (0.40)	0.19 [0.50]
Δ*l*	1.78 (0.18)	1.10 (0.29)	-	20.22 (0.00)***	0.80 (0.37)	0.21 (0.64)	66.51 [0.16]
Δ*re*	0.41 (0.52)	0.10 (0.74)	4.91 (0.02)**	-	1.07 (0.30)	0.07 (0.78)	2.57 [0.82]
Δ*rx*	8.08 (0.01)***	2.85 (0.09)*	0.06 (0.79)	0.44 (0.50)	-	0.22 (0.63)	−0.23 [0.05]*
Δ*fd*	0.20 (0.65)	0.60 (0.43)	1.57 (0.21)	1.97 (0.16)	2.49 (0.116)	-	−0.11 [0.04]**

Lag length: 2. P value for F-statistic and t-statistic are listed in parentheses and brackets, respectively. In the table ECT indicates the error correction term. ***Indicate statistical significance at the 1% level, **Indicate statistical significance at the 5% level, *Indicate statistical significance at the 10% level, ECT: Error correction term

Table 6: Panel group mean cointegration: FMOLS and DOLS long-run estimates elasticities

Variables	FMOLS	t-statistics	DOLS	t-statistics
K	0.022	2.656***	0.032	2.700***
L	0.385	6.969***	0.424	6.747***
Re	0.155	6.841***	0.143	7.020***
Rx	0.456	14.739***	0.433	14.948***
Fd	−0.184	−2.900***	−0.193	−2.555**

Trend assumptions: Trend and no deterministic intercept. ***Indicate statistical significance at the 1% level, **Indicate statistical significance at the 5% level. FMOLS: Fully modified ordinary lest squares, DOLS: Dynamic ordinary lest squares

reflecting a positive impact on economic growth. This later is affected negatively and statically significantly at 1% level by the private sector credit. This fact indicates that the FD plays a regulator role in the long-run dynamics. As a political monetary indicator for the GCC countries, it reduces in this regard the height increase of wage and inflation rates related to the inflationary gap.

For the FMOLS results, a 1% increase in capital increases output by 0.022%. A 1% increase in labor raises output by 0.385%. A 1% increase in renewable energy consumption increases output by 0.155%. A 1% increase in exports enhances output by 0.456%. However, a 1% increase in private sector credit decreases output by 0.184.

7. CONCLUSION

This paper investigates empirically the causal relationship between renewable energy consumption, real GDP, trade and FD for the GCC countries during the period 1980-2012. As major oil-exporters in the world, the GCC countries account for 52% of the total OPEC oil reserves and 49% of the total OPEC. Although, oil represents approximately 41% of GDP and the energy consumption is not expensive, there is a trend toward energy conservation policies and more interest for the use of renewable energy. The purpose of this paper is to examine the linkages between renewable energy consumption, real GDP and trade openness. Compared to previous studies in the literature related to the relationship between energy consumption and economic growth, our paper offers a more comprehensive analysis of these issues by including FD as macroeconomic factors. The use of this production factor allows us to better understand the relationship between renewable energy consumption and economic growth. In order to achieve the objective of this study, we employed the panel cointegration approach to examine the short-run and long-run causality between renewable energy consumption, real GDP, trade and FD.

Both short and long-run Granger causality test results make evidence of positive bidirectional causality between output and exports. These empirical finding strongly indicates that promoting exports allows to increase both exports and economic growth. Furthermore, the obtained results indicate that there is short-run unidirectional causality running from output and exports to capital.

The long-run estimated results indicate that there is evidence of causality linkages from capital, labor, renewable energy consumption, exports and private sector credit to output. Also, we find a long-run causality from output, capital, labor, renewable energy consumption and private sector credit to exports. Additionally, private sector credit receives long-run effect from output, capital, labor, renewable energy consumption and exports. This empirical result indicates that the renewable energy use, promoting exports and FD are able to increase the economic growth for the GCC countries. Besides, the long-run elasticities result shows positive impact of all variables except private sector credit on output. Our finding shows that although the private sector credit is an important catalyst in the short-run dynamics. It can play a regulator role in the long-run dynamics as a political monetary indicator to mitigate the height increase of wage and inflation rates related to the inflationary gap.

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