Salih Katircioğlu[1], Dilber Çağlar[2], Demet Beton Kalmaz[3]

TRADE, ENERGY AND GROWTH IN G7 COUNTRIES

The main aim of this paper is to investigate the relationship between energy consumption and trade by using econometric analysis for G7 countries covering the period 1960-2010, as those countries are very important actors of the global economy since they all together represent around 90% of global GDP and 80% of global trade. Time series analysis is used to examine the relations between the variables. The present study investigates that real income and international trade are important determinants of energy consumption in G7 countries. The evidence found in this paper could be used to shape the energy policies in G7 countries.

Keywords: *energy consumption; trade; economic growth; causality; G7.*

Салі Катірджіоглу, Ділбер Джаглар, Демет Бетон Калмаз

ТОРГІВЛЯ, ЕНЕРГЕТИКА І РОЗВИТОК У КРАЇНАХ "ВЕЛИКОЇ СІМКИ"

У статті за допомогою економетричого аналізу розглянуто залежність між енергоспоживанням і торгівлею в країнах "великої сімки" за період 1960-2010 рр., оскільки ці країни — важливі учасники світової економіки, разом вони представляють близько 90% світового ВВП і 80% світової торгівлі. Для дослідження залежності між змінними використано аналіз часових рядів. Показано, що реальний дохід і міжнародна торгівля — важливі визначальні чинники енергоспоживання в країнах "великої сімки". Дані статті можуть бути використані при перегляді енергетичної політики цих країн.

Ключові слова: *енергоспоживання; торгівля; економічний розвиток; причинність; країни "великої сімки".*

Сали Катирджиоглу, Дилбер Джаглар, Демет Бетон Калмаз

ТОРГОВЛЯ, ЭНЕРГЕТИКА И РАЗВИТИЕ В СТРАНАХ "БОЛЬШОЙ СЕМЕРКИ"

В статье с помощью эконометрического анализа рассмотрена зависимость между энергопотреблением и торговлей в странах "большой семерки" за период 1960-2010 г.г., поскольку эти страны — важные участники мировой экономики, вместе они представляют около 90% мирового ВВП и 80% мировой торговли. Для исследования зависимости между переменными использован анализ временных рядов. Показано, что реальный доход и международная торговля — важные определяющие факторы энергопотребления в странах "большой семерки". Данные статьи могут быть использованы при пересмотре энергетической политики этих стран.

Ключевые слова: *энергопотребление; торговля; экономическое развитие; причинность; страны "большой семерки".*

Introduction. Investigation on energy issues, environmental pollution and economic growth has found considerable attention of researchers. However, the relationship of energy with particular segments or sectors of the economy deserves attention. International trade is one of them. For some countries it is found that international trade is the engine of economic growth while it hasn't been investigated so in

[1] Eastern Mediterranean University, Famagusta, Northern Cyprus.
[2] Girne American University, Kyrenia, Northern Cyprus.
[3] European University of Lefke, Northern Cyprus.

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some others (Katircioglu, 2009). A development in international trade not only contributes to the income of economies but also leads to an increase in the level of energy especially in energy-importing countries. It is likely that international trade might be statistically related to energy consumption.

The purpose of this paper is to investigate the long-run equilibrium relationship between international trade, real income and energy consumption. This study is important due to two reasons. Firstly, empirical relationship between trade and energy consumption deserves more investigation in the literature, and secondly, G7 countries comprise 50.4% of the global nominal GDP, therefore, the results of the present study will be important for policy makers. To analyze the impact of trade and real income on energy demand in G7[1] countries the bounds tests and conditional error correction models are employed. Empirical models are estimated by using time-series data for each country separately covering the years between 1960 and 2010. The following sections of the paper set out the summary of the literature on trade and energy consumption, theoretical setting, data and methodology, empirical results and conclusion.

Literature Review. Even though there have been several studies focusing on the relationship between energy consumption and economic growth and the relationship between trade (import-export) and economic growth, there are few studies analyzing the relationship between trade and economic growth.

There are two different results found in literature about the relationship between energy consumption and economic growth. The first group of these results showed no causal relationship exists between energy consumption and economic growth (Akarca and Long, 1980; Erol and Yu, 1987; Yu and Hwang, 1984; Yu and Choi, 1985; Masih and Masih, 1996; Cheng, 1996; Stern, 1993, 2000; Soytas and Sari, 2003; Lee, 2006; Joyeux and Ripple, 2007). The second group of those studies found a causal relationship between those variables but the way of Granger causality between energy consumption and economic growth differs among the studies depending on countries and methodologies under consideration. Those studies gained importance with the study of Kraft and Kraft in 1978. They estimated unidirectional causality from economic growth to energy consumption by using the USA data covering the time period between 1947 and 1974. In some of those studies unidirectional causality from economic growth to energy consumption estimated (Erol and Yu, 1987; Abosedra and Baghestani, 1989; Cheng and Lai, 1997; Jumbe, 2004; Al-Irani's, 2006; Lee and Chang's, 2008; Mehrara's, 2007; Huang et al., 2008; Akinlo, 2008; Chiou-Wei et al, 2008), while the results of other studies indicated that energy consumption causes economic growth (Erol and Yu, 1987; Masih, 1996; Glasure and Lee, 1997; Masih and Masih, 1997; Soytas, Sari and Ozdemir, 2001; Soytas and Sari, 2003; Lee, 2005; Mahadevan and Asafu-Adjaye, 2007; Narayan and Smyth, 2008; Chiou-Wei et al., 2008; Lee and Chang, 2008; Apergis and Payne, 2009). On the other hand the rest of those studies estimated bidirectional relationship between the variables (Nachane et al., 1988; Masih, 1997; Yang, 2000; Oh and Lee, 2004; Paul and Bhattacharya, 2004; Ghali and El-Sakka, 2004; Lee and Chang, 2008).

[1] Canada, France, Germany, Italy, Japan, UK and USA.

Even the literature on energy consumption and economic growth is plenty there are only few studies analyzing the relationship between trade and energy consumption. The studies examining the relationship between trade and energy consumption were started by Narayan and Smyth in 2008, by taking electricity consumption as a variable instead of total energy consumption. They examined the relationship between electricity consumption and exports for 6 Middle East countries using the panel data covering the years between 1974 and 2002. As a result of the study for short-run analysis, they found a Granger causality running from energy consumption to real income and real income to exports. They also found a Granger causality relationship running from exports and electricity consumption to real income and from exports and real income to electricity consumption. The first study that examined the relationship between trade, economic growth and total energy consumption was carried by Sadorsky in 2011. He examined the relationship between economic growth, energy consumption and exports/imports for 8 Middle East by using a panel data covering the years 1980 and 2007. The estimation results for short-run analyses showed a Granger causality running from income to energy and from exports to energy for the energy equation, from energy consumption to income and from exports to income for the income equation, and, income to exports for the export equation.

Theoretical Setting. To investigate the relationship between energy consumption and economic growth and trade, we treated the energy consumption as the function of economic growth, imports and exports separately:

$$E_t = f(Y_t, M_t, X_t), \quad (1)$$

where E denotes the total energy consumption, while Y is the real GDP, M indicates the value of total imports, X denotes value of total exports and the subscript t denotes the time period.

The model estimating the long term relationship between the dependent and independent variables are produced by taking the natural logarithms of the variables and adding a random error term as follows;

$$\ln E_t = \beta_0 + \beta_1 \ln GDP_t + \beta_2 \ln M_t + \beta_3 \ln X_t + \varepsilon \quad (2)$$

In equation (2) the subscript t denotes the time period while a stochastic error term is denoted by ε. Error correction model (ECM) is applied to investigate the long-run relations so that the long-run behavior of the endogenous variables to converge to their long-run relationships is restricted while allowing for short-run adjustment dynamics. The additional term included into the model is called the error correction component which corrects the deviations from long-run equilibrium through a series of partial short run adjustments. In other words, the error component included into the model indicates how much the difference of the long run and short run energy consumption will be decreased by the changes in imports, exports and GDP growth.

Data and Methodology.

Data. The data we have employed in this study are time series data. For France and the USA the data covering the time period from 1960 to 2010 is applied since the

data for those years are available from the World Development indicators, while for the other countries the available data covers the years between 1970 and 2010. We have used 4 variables for the G7 countries. These are:

E_t = energy use (kt equivalent) at time *t;*

GDP_t = real gross domestic product at time *t;*

X_t = real exports of goods and services at time *t;*

M_t = real imports of goods and services at time *t.*

Energy consumption is measured by energy use in kt of oil equivalent per capita, real GDP per capita is measured in constant international dollars. The data for exports and imports of goods and services are measured in constant US dollars.

The growth trend of the related variables suggesting that long-run relationship has high probability to exist in the study since all the series tend to move very closely together over time in all the countries. Energy consumption shows an increasing trend in Canada, France, Italy, Japan and USA. In Italy and Japan even the trend of energy consumption is increasing, it is found that there had been a slight decrease between the years 2007 and 2010, starting to increase in 2010 again. On the other hand the growth of energy consumption in Germany and the UK shows a stable trend. Exports are found to be increasing between 1970 and 2010 in France and Germany, while in other countries it is observed that even the value of the exports increased till 2007, it showed a decreasing trend till 2010. Imports are increasing for all the countries but except from Canada, Germany and France it is observed to decrease between 2007 and 2010. GDP showed an increasing trend for all countries under consideration of this paper.

The variables used in this study are similar to those used in the paper by Sadorsky (2011). The variables are transferred to their natural logarithms to be able to make the first differences to approximate their growth rates. The logarithmic forms of the variables are illustrated by putting 'ln' in front of each variable, such as ln E_t, ln GDP_t, ln X_t, and ln M_t. The first differences of the variables are determined by putting 'd' in front of each of them.

Unit Root Tests for Stationarity. The first step before starting the empirical analysis of the model applied to estimate the relationships among variables is to test the stationarity of the variables. Stationarity test is very important to test the integration level and the possible cointegration among variables. The stationarity of the variables are tested by applying the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) (1992) unit root test. Different methods are available in the literature to test stationarity. The most popular ones are the augmented Dickey-Fuller (ADF), Phillips-Perron and Phillips-Schmidt-Shin (KPSS) (1992) unit root test. In this study the KPSS unit root test is applied to test whether the variables are stationary or not. The reason to choose KPSS is that this test is superior to PP and ADF tests. Table 1 reports the KPSS test results for stationarity in the selected series. Tests results indicate that dependent variable, which is the energy variable, for all countries are integrated of order one at 5% critical value except the UK. The dependent variable for the UK is integrated of order one at 10% critical value. The independent variables, GDP, imports and exports, are mix order of integration across the G7 countries.

Table 1. **The KPSS Test for Unit Roots: with constant and trend**

Variables	Test statistics & Critical Values &Integration levels							
	LnEnergy		LnGDP		LnExports		LnImports	
	KPSS (test stat)	Integration levels	KPSS (test stat)	Integration levels	KPSS (test stat)	Integration levels	KPSS (test stat)	Integration levels
Canada	0.213	I(1)	0.099	I(0)	0.111	I(0)	0.097	I(0)
France	0.211	I(1)	0.227	I(1)	0.184	I(1)	0.179	I(1)
Germany	0.216	I(1)	0.190	I(1)	0.188	I(1)	0.178	I(1)
Italy	0.190	I(1)	0.236	I(1)	0.156	I(1)	0.126	I(0)
Japan	0.202	I(1)	0.209	I(1)	0.191	I(1)	0.097	I(0)
UK	0.123	I(1)	0.108	I(0)	0.073	I(0)	0.147	I(1)
USA	0.165	I(1)	0.184	I(1)	0.095	I(0)	0.073	I(0)

Bounds Tests. Since regressors of the present study are mixed ordered of integration, bounds tests as developed by Pesaran et al. (2001) under the ordinary least squares (OLS) based autoregressive distributed lag (ARDL) approach is applied to test the level relationships. The following model will be estimated in this respect:

$$\Delta \ln E_t = a_{0_E} + \sum_{i=1}^{n} b_{i_E} \Delta \ln E_{t-1} + \sum_{i=1}^{n} c_{i_E} \Delta \ln GDP_{t-1} + \sum_{i=1}^{n} d_{i_E} \Delta \ln X_{t-1} + \sum_{i=1}^{n} e_{i_E} \Delta \ln M_{t-1} + \sigma_{1_E} \ln E_{t-1} + \sigma_{2_E} \ln GDP_{t-1} + \sigma_{3_E} \ln X_{t-1} + \sigma_{4_E} \ln M_{t-1} + \varepsilon_{1t} \quad (3a)$$

$$\Delta \ln GDP_t = a_{0_{GDP}} + \sum_{i=1}^{n} b_{i_{GDP}} \Delta \ln GDP_{t-1} + \sum_{i=1}^{n} c_{i_{GDP}} \Delta \ln E_{t-1} + \sum_{i=1}^{n} d_{i_{GDP}} \Delta \ln X_{t-1} + \sum_{i=1}^{n} e_{i_{GDP}} \Delta \ln M_{t-1} + \sigma_{1_{GDP}} \ln GDP_{t-1} + \sigma_{2_{GDP}} \ln E_{t-1} + \sigma_{3_{GDP}} \ln X_{t-1} + \sigma_{4_{GDP}} \ln M_{t-1} + \varepsilon_{1t} \quad (3b)$$

$$\Delta \ln X_t = a_{0_X} + \sum_{i=1}^{n} b_{i_X} \Delta \ln X_{t-1} + \sum_{i=1}^{n} c_{i_X} \Delta \ln E_{t-1} + \sum_{i=1}^{n} d_{i_X} \Delta \ln GDP_{t-1} + \sum_{i=1}^{n} e_{i_X} \Delta \ln M_{t-1} + \sigma_{1_X} \ln X_{t-1} + \sigma_{2_X} \ln E_{t-1} + \sigma_{3_X} \ln GDP_{t-1} + \sigma_{4_X} \ln M_{t-1} + \varepsilon_{1t} \quad (3c)$$

$$\Delta \ln M_t = a_{0_M} + \sum_{i=1}^{n} b_{i_M} \Delta \ln M_{t-1} + \sum_{i=1}^{n} c_{i_M} \Delta \ln E_{t-1} + \sum_{i=1}^{n} d_{i_M} \Delta \ln GDP_{t-1} + \sum_{i=1}^{n} e_{i_M} \Delta \ln X_{t-1} + \sigma_{1_M} \ln M_{t-1} + \sigma_{2_M} \ln E_{t-1} + \sigma_{3_M} \ln GDP_{t-1} + \sigma_{4_M} \ln X_{t-1} + \varepsilon_{1t} \quad (3d)$$

Each equation from (3a) to (3d) applied for 7 times separately for each country under consideration since the subscript *i* is used to indicate the each of G7 countries (*i*=1,.....,7). Bounds test consists of two main stages. The first stage is to examine the long-run relationship of the variables by estimating the unrestricted error correction regressions given by equations (3a) (3b) (3c) and (3d), with respect to equation (2). These equations are estimated for long-run without informing us about the direction of the relationships. F-test is used for hypothesis testing. The null hypothesis indicates no long-run relationship among the variables, while the alternative hypothesis indicate there is a long-run relationship existing among the variables.

Hypothesis testing for equation (3a), (3b), (3c) and (3d);

$$H_o : \sigma_{1y} = \sigma_{2y} = \sigma_{3y} = \sigma_{4y} = 0,$$

$$H_a : \sigma_{1y} \neq \sigma_{2y} \neq \sigma_{3y} \neq \sigma_{4y} \neq 0,$$

The critical values for the F-test are taken from Narayan and Narayan (2005), which is a generated form of the critical values developed by Pesaran et al. (2001), since the critical values developed by Pesaran et al. (2001) cannot be applied in case of small sample sizes. If the computed F-statistics is inbetween upper and lower limits of the F-critical values then the analysis is said to be inconclusive. If the empirical analysis shows that the estimated F-statistics is lower than the lower bound of the critical values, then the null hypothesis of no long run relationship is not rejected, while if the estimated F-statistic is upper than the upper bound of the critical values then the null hypothesis is rejected indicating long-run relationship among the variables. If there is no long-run relationship among the variables it is denoted by *a*, if the test result is inconclusive then it is denoted by *b* and if there is a long-run relationship between the variables it is denoted by *c* in Table 2.

There are 5 different cases taken under consideration during the bounds tests. In this paper only 3 of those are considered since only those 3 give reliable results. Case III indicates that the test is applied by excluding the trend and including unrestricted intercept. Case IV includes intercept and restricted trend, while case V applies the test by including intercept and unrestricted trend. T-statistics are only used for cases III and V to test whether we should include restriction on trend, so t-statistics can only be applied in case either if there is an unrestricted trend or no trend.

According to the bounds tests results, as presented in Table 2, there is no long-run relationship found among the variables for Germany and the UK, which indicates GDP, exports and imports are not in long-run relationship with energy consumption for those two countries. On the other hand, there is a long-run relationship of the independent variables with energy consumption found for Canada, France, Italy, Japan and the USA.

Table 2. **The Bounds Tests for level relationship under 3 scenarios**

After the long-run relationship among variables is found, the conditional ECM using the ARDL approach is employed to estimate the short-run deviation of the series from its long-run equilibrium path. The model can be written as follows:

$$\Delta \ln Y_t = \Delta\beta_0 + \sum_{j=1}^{p-1} \phi_j \Delta \ln Y_{t-i} + \sum_{i=1}^{k} \beta_{i_0} \Delta \ln X_{it} + \sum_{i=1}^{k} \sum_{j=1}^{q-1} \beta_{ij} \Delta \ln X_{i,t-j} + \varphi \Delta Z_t + \gamma(1,p) ECT_{t-1} + u_t \quad (4)$$

Δ is the first difference operator, while ϕ_j, β_{ij} and φ are used to denote the coefficients relating to the short-run dynamics of the model's convergence to the equilibrium. $\gamma(1, p)$ indicates the speed of adjustment. Long-run relationship is a sign for a causal relationship among variables at least in one direction. Since there is no prior information about the direction of the long-run relationship among the variables, to estimate the direction of the causal relationship the conditional Granger causality test is carried out under the ECM model taking each of the variables in turn as a dependent variable as described by equations (5a), (5b), (5c) and (5d).

Table 2. **The Bounds Tests for level relationship under 3 scenarios**

	With Intercept and Restricted Trend	With Intercept and Unrestricted Trend		Without Deterministic Trend and with Unrestricted Intercept		Conclusion
Variables	F_{iv}	F_v	t_v	F_{iii}	t_{iii}	H_0
(1)Canada F_E(E/GDP,X,M)	8,317c	9,360c	-5,172c	11,314c	-5,395c	Rejected
(2)France F_E(E/GDP,X,M)	3,93c	4,88c	-3,963a	3,614b	-2,454a	Rejected
(3)Germany F_E(E/GDP,X,M)	2,136a	2,467a	-3,000b	2,765a	-3,082c	Not Rejected
(4)Italy F_E(E/GDP,X,M)	4,921c	6,007c	-4,756c	3,971c	-3,684c	Rejected
(5)Japan F_E(E/GDP,X,M)	3,884c	3,896b	-2,679a	5,084c	-2,808a	Rejected
(6)UK F_E(E/GDP,X,M)	2,245a	2,804a	-2,286a	2,846a	-2,583a	Not Rejected
(7)USA F_E(E/GDP,X,M)	5,254c	3,650b	-3,419c	5,277c	-2,879b	Rejected

The Granger causality test is regressed by using the following equations:

$$\Delta \ln E_{it} = \alpha_{1i} + \sum_{j=1}^{q} \varphi_{11j} \Delta E_{it-j} + \sum_{j=1}^{q} \varphi_{12j} \Delta GDP_{it-j} + \sum_{j=1}^{q} \varphi_{13j} \Delta X_{it-j} + \sum_{j=1}^{q} \varphi_{14j} \Delta M_{it-j} + \delta ECT_{it-1} + u_{1it} \quad (5a)$$

$$\Delta \ln GDP_{it} = \alpha_{2i} + \sum_{j=1}^{q} \varphi_{21j} \Delta GDP_{it-j} + \sum_{j=1}^{q} \varphi_{22j} \Delta E_{it-j} + \sum_{j=1}^{q} \varphi_{23j} \Delta X_{it-j} + \sum_{j=1}^{q} \varphi_{24j} \Delta M_{it-j} + \delta ECT_{it-1} + u_{2it} \quad (5b)$$

$$\Delta \ln X_{it} = \alpha_{3i} + \sum_{j=1}^{q} \varphi_{31j} \Delta X_{it-j} + \sum_{j=1}^{q} \varphi_{32j} \Delta GDP_{it-j} + \sum_{j=1}^{q} \varphi_{33j} \Delta E_{it-j} + \sum_{j=1}^{q} \varphi_{34j} \Delta M_{it-j} + \delta ECT_{it-1} + u_{3it} \quad (5c)$$

$$\Delta \ln M_{it} = \alpha_{4i} + \sum_{j=1}^{q} \varphi_{41j} \Delta M_{it-j} + \sum_{j=1}^{q} \varphi_{42j} \Delta GDP_{it-j} + \sum_{j=1}^{q} \varphi_{43j} \Delta X_{it-j} + \sum_{j=1}^{q} \varphi_{44j} \Delta E_{it-j} + \delta ECT_{it-1} + u_{4it} \quad (5d)$$

Each equation from (5a) to (5d) applied 7 times separately for each country under consideration since the subscript *i* is used to indicate each of G7 countries (*i*=1,.....,7). The empirical results of the Granger causality test is summarized in Table 3.

As it was mentioned before, according to the bounds tests there is no long-run relationship found among the variables for Germany and the UK, which indicates that GDP, exports and imports are not in long-run relationship with energy consumption for those two countries. Since there is no causal relationship found for those countries, the Granger causality test is run for Canada, France, Italy, Japan and the USA. According to the estimation results energy consumption is found to converge to its long-term equilibrium level at a high degree by the contribution of GDP, imports and exports in those countries under consideration. Highest convergence is obtained for Canada (200%).

Empirical Results. The estimation results are summarized on each of the following tables where each table gives the estimation results for the equations (5a), (5b), (5c) and (5d) where the dependent variable varies according to the model. Table 3 gives the estimation results for ECT coefficient, t-statistics for ECT in Granger causality and level coefficients for the independent variables where energy consumption was taken as the dependent variable.

Table 3. **Energy Consumption is the dependent variable**

Null Hypothesis	ECT coefficient	t-stat for ECT in Granger causality	Level Coefficient		
			GDP	X	M
Canada F_E(E/GDP, X, M)	-2.00*	-2.120**	0.464*	-0.018	0.076*
France F_E(E/GDP, X, M)	-0.237*	-2.954*	1.049*	-0.081	0.146
Germany F_E(E/GDP, X, M)	-	-	-	-	-
Italy F_E(E/GDP, X, M)	-0.431*	-2.099**	-0.320	0.193***	0.412*
Japan F_E(E/GDP, X, M)	-0.273*	-4.437*	0.866*	-0.373*	0.312*
UK F_E(E/GDP, X, M)	-	-	-	-	-
USA F_E(E/GDP, X, M)	-0.110*	-3.688*	0.195	0.239	0.721*

Table 4 summarizes the estimation results for ECT coefficient, t-statistics for ECT in Granger causality and level coefficients for the independent variables where GDP growth was taken as the dependent variable.

Energy consumption converges to its long-term equilibrium level at high levels by the contribution of GDP, exports and imports for all the countries except Germany and the UK in the models that energy consumption is taken as dependent variable. Highest convergence estimated for Canada (200%). Elasticity of GDP and imports are statistically significant for energy consumption in Canada indicating that 1% change in GDP increases energy consumption by 0.46% in the long run while change in imports leads to 0.076% increase in energy consumption in Canada. In case of France elasticity of GDP is statistically significant for energy consumption suggesting that 1% increase in GDP promote the increase in energy consumption by 1.05% in the long run. According to the estimation results it is found that both elasticity of exports and imports are statistically significant in Italy having positive effect on energy consumption. It is found in Japan that all the coefficients are statistically significant. Increase in imports and GDP lead to an increase in energy consumption while 1% increase in imports decreases energy consumption by 0.37%. In the USA only the elasticity of imports found to be statistically significant indicating that 1% increase in imports will increase the energy consumption by 0.72%.

Table 4. **GDP is the dependent variable**

Null Hypothesis	ECT coefficient	t-stat for ECT in Granger causality	Level Coefficient		
			ENERGY	X	M
Canada F_{GDP}(GDP/E, X, M)	-0.135**	-1.724***	0.639***	0.035	0.040
France F_{GDP}(GDP/E, X, M)	-0.160*	-1.738*	0.369*	-0.129	0.426*
Germany F_{GDP}(GDP/E, X, M)	-	-	-	-	-
Italy F_{GDP}(GDP/E, X, M)	-0.047*	-2.247**	-0.026	0.187	0.166
Japan F_{GDP}(GDP/E, X, M)	-0.108*	-3.490*	0.558	0.498*	-0.401**
UK F_{GDP}(GDP/E, X, M)	-	-	-	-	-
USA F_{GDP}(GDP/E, X, M)	-0.137*	-1.879***	-0.051	0.215	0.265

According to the estimation results where exports was taken as dependent variable as summarized in Table 5, GDP converges to its long-term equilibrium level at high levels by the contribution of energy consumption, exports and imports for all the countries except Germany and the UK in the models that GDP is taken as dependent variable. In Canada only the elasticity of energy consumption found to be significantly has a positive effect on GDP while in France both energy consumption and imports have significant and positive effects on GDP growth rate. For Italy and the USA none of the variables found to have any statistically positive effect on GDP growth in the long run. In Japan it is estimated that elasticity of both exports and imports have statistically significant effect on GDP growth. 1% increase in exports leads to 0.50% increase in GDP growth while 1% increase in imports estimated to decrease GDP growth by 0.40%.

Table 5. **Exports is the dependent variable**

Null Hypothesis	ECT coefficient	t-stat for ECT in Granger causality	Level Coefficient		
			ENERGY	GDP	M
Canada F_X(X/GDP, E, M)	-0.041*	-1.554	9.124	-2.230	-0.762
France F_X(X/GDP, E, M)	-0.204*	-0.455	0.603	0.354	0.666**
Germany F_X(X/GDP, E, M)	-	-	-	-	-
Italy F_X(X/GDP, E, M)	-0.453*	-2.214**	1.652***	1.045**	-0.086
Japan F_X(X/GDP, E, M)	-0.104*	0.589	0.199	1.073	0.770
UK F_X(X/GDP, E, M)	-	-	-	-	-
USA F_X(X/GDP, E, M)	-0.444*	-2.013**	1.031*	0.398	-0.904*

According to the estimation results where exports is used as dependent variables, exports converges to its long-term equilibrium level at high levels by the contribution of energy consumption, GDP and imports for all the countries except Germany and the UK. In Canada and Japan no statistically significant effect of variables found on exports, while in France only the elasticity of imports is found to have significant positive effect on exports suggesting that 1% increase in imports leads to 0.66% increase in exports. In Italy both energy consumption and GDP estimated to have statistically significant coefficients which have positive effect on exports. The estimation results for the USA are statistically significant suggesting that as energy consumption increase by 1% causes exports increase by 1.03% and as imports increase by 1%, exports decrease by 0.90% in the long term.

Table 6. **Imports is the dependent variable**

Null Hypothesis	ECT coefficient	t-stat for ECT in Granger causality	Level Coefficient		
			ENERGY	GDP	X
Canada F_{GDP}(GDP/E, X, M)	-0.185*	-1.965**	-10.365	4.515	0.172
France F_{GDP}(GDP/E, X, M)	-0.294*	-0.436	-0.243	0.818	0.800*
Germany F_{GDP}(GDP/E, X, M)	-	-	-	-	-
Italy F_{GDP}(GDP/E, X, M)	-0.602*	-0.736	0.862*	0.967*	-0.027
Japan F_{GDP}(GDP/E, X, M)	-0.376*	-0.523	2.026*	-0.879**	-0.009
UK F_{GDP}(GDP/E, X, M)	-	-	-	-	-
USA F_{GDP}(GDP/E, X, M)	-0.181*	-1.007	0.146	2.049*	-0.009

The estimation results of the model where imports is used as dependent variables are summarized in Table 6. It is estimated that imports also converges to its long-term equilibrium level at high levels by the contribution of energy consumption, GDP and exports for all the countries except Germany and the UK. In Canada none of the variables are found to have a statistically significant effect on imports in the long run.

In France only the elasticity of exports found to be statistically significant for imports and suggests that 1% increase in exports leads to 0.80% increase in imports in the long run. Both in Italy and Japan energy consumption and GDP growth found to be statistically significant. In both countries it is estimated that increase in energy consumption leads to increase also in imports, however, GDP estimated to have positive effect in Italy while it has negative effect in Japan on imports in the long run. According to the estimation results for the USA elasticity of GDP is statistically significant for imports and it suggests that 1% change in GDP will lead to a 2.05% change in imports in the same direction.

According to the estimation results of Granger causality test for energy consumption, exports, imports and GDP in Canada, it is found that there are 4 bilateral Granger causality relationships. Those causality relationships indicate there exists bidirectional causality between imports and GDP, between imports and exports, between energy consumption and GDP, and between energy consumption and exports. In addition to those bidirectional relationships between variables in Canada, there is also unidirectional casual relationship running from energy consumption to imports. In case of France there is no causal relationship found between variables while there is only imports to energy consumption unidirectional causal relationship found in Italy. For Japan there is a bidirectional causality found between imports and energy consumption. It is also estimated that there are unidirectional causal relationships from exports to imports, GDP to imports, GDP to energy consumption and from exports to energy consumption. The estimation results of the Granger causality test for the USA suggest there are a bidirectional causal relationship between imports and exports, and between exports and energy consumption. The results also showed a unidirectional causal relationship from GDP to energy consumption and from energy consumption to exports.

Conclusion. The present study investigates econometric relationship between energy consumption, trade, and growth in G7 countries for the 1960-2010 period. The latest econometric techniques are employed with this respect. Bounds tests to level relationships suggest that energy consumption in G7 countries are in long-term relationship with real income and international trade; this means that real income, exports, and imports are long-term determinants of energy consumption in G7 countries. This finding is also the same when GDP is dependent variable and when exports are dependent variable; that is energy consumption and international trade are long-term determinants of real income of G7 countries. Secondly, conditional error correction models of the present study reveal that energy consumption in G7 countries converge to its long-term level significantly by the contribution of real income and international trade. Furthermore, real income also converges to its long-term level by the contribution of energy consumption and international trade in G7 countries. And, exports also converge to its long-term level by the contribution of GDP, energy consumption, and imports. Finally, results of conditional Granger causality tests confirm the existence of various long-term causalities between energy consumption, real income, and international trade in G7 countries. If summarized, energy consumption, real income, and international trade are long-term determinants of each other in G7 countries and they do possess feedback relationship.

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