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SCHOOL OF BUSINESS ADMINISTRATION WORKING PAPER SERIES

SBAWPS: 05-05/2015

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Working Paper 05-05/2015

School of Business Administration
Working Paper Series (SBA WPS)

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Abstract

The purpose of this research is to investigate the causal relation between energy use and economic growth in one of the MENA countries, Jordan using annual data over the period 1975-2007. The methodology used in this study follows Toda and Yamamoto (1995) procedure in order to test the Granger causality between economic growth and energy use. The empirical results reveal that economic growth Granger causes energy use in Jordan. Thus, these findings lend support to the hypothesis that economic growth positively affects energy use therefore energy conservation policy may not slow the growth in the economy.

Keywords: Energy use; Economic growth; Causality, Jordan

1. Introduction

The review of the literature shows that the relationship between energy use and economic growth has been widely investigated. However, the empirical literature shows that the direction of causality between energy use and economic growth is still debatable (Payne 2010). For example, empirical studies such as, among others, Masih and Masih (1996), Lee (2005), Soytas and Sari (2003), Yoo (2006), Squalli (2007), Akinlo (2008), Chiou-Wei et al. (2008), and Chontanawat et al. (2008) reported mixed results with respect to the direction of causality between energy use and economic growth. That is, the findings of empirical studies on the direction of the causal relation between energy use and economic growth vary and can take one of the following forms. First, unidirectional causal relation from energy use to economic growth (see for example, among others, Shiu and Lam (2004), Altinay and Karagol (2005), Narayan and Singh (2007), Yuan et al. (2007), Narayan and Smyth (2009), Abosedra et al. (2009), Odhiambo (2009), and Tsani (2010). Second, unidirectional causality from economic growth to energy use (see for example, Ghosh (2002), Oh and Lee (2004), Lise and Van Montfort (2007), Mehrara (2007), and Mozumder and Marathe (2007), among others). Third, bidirectional causality has been found between energy use and economic growth; see for example, among others, Ghali and El-Sakka (2004), Erdal et al. (2008), Tang (2008), Belloumi (2009), and Dagher and Yacoubian (2012). And Fourth, the neutrality hypothesis which means that no such causal relation between economic growth and energy use exists as found in Yu and Hwang (1984).

Jordan as classified by the World Bank, is among the lower-middle-income economies in the world. In addition, it is classified by the World Bank as resource-poor, labor-abundant (RPLA) country. Jordan economy is dependent on energy for its development thus the relationship between energy use and economic growth is essential for economic development in

Jordan. Thus, this research will focus on examining the causal relationship between energy use and economic growth in Jordan in order to provide the policymakers in the country with a planning tool that can help them in formulating their policies to promote economic growth, and whether or not the growth (conservation) in energy use can promote (retard) economic growth in Jordan.

The purpose of this paper is to investigate the direction of the causal relationship between energy use and economic growth for Jordan as one of the Middle Eastern & North African Countries (MENA) over the period 1975 to 2007 using a newly developed procedure of Granger non-causality by Toda and Yamamoto (1995). In light of recent budgetary problems, our investigation should help identify structural adjustments and proper reforms to cope more efficiently with the current challenges facing the country.

The rest of the paper is organized as follows. Section 2 presents data and the empirical methodology used in the study. Section 3 discusses the empirical results while section 4 concludes the study.

2. **Data and Methodology**

The paper will use annual data for the period 1975-2007 and the variables of this study are real gross domestic product per capita (RGDPPC) (in constant local currency units) and energy use per capita (EUPC) (in kg of oil equivalent per capita). Data on these variables are extracted from the World Bank, World Development Indicators (online).

Granger non-Causality Test: The Toda-Yamamoto Approach

The methodology used in this study follows Toda and Yamamoto (1995) procedure in order to test the Granger non-causality between economic growth and energy use. As an advantage of this method, Toda and Yamamoto (1995) stated that "Our method is applicable whether the VAR's may be stationery (around a deterministic trend), integrated of arbitrary order, or cointegrated of an arbitrary order. Consequently, one can test linear or nonlinear restrictions on the coefficients by estimating a levels VAR and applying the Wald criterion, paying little attention to the integration and cointegration properties of the time series data in hand (Toda and Yamamoto (1995), p.227)". This procedure involves two steps. First, determine the lag length (k) of the VAR model and augment that with the maximum order of integration (dmax) of the variables used in the model. We used both Akaike Information Criterion (AIC) and Schwarz criterion (SC) to determine the optimal lag structure (k) of the VAR model. We also used the Augmented Dickey-Fuller (ADF) test to determine the order of integration (dmax) of the variables used in the model. Second, test for Granger causality by using the modified Wald (MWALD) test in order to test the coefficients of the first k coefficients of the VAR (k+dmax). This test, according to this procedure of causality developed by Toda and Yamamoto (1995), has an asymptotic Chi-square distribution when a VAR (k+dmax) is estimated (given that dmax is the maximum order of integration that is suspected to occur in the system). Zapata and Rambaldi (1997) argued that the MWALD test requires no priori knowledge of cointegration or no cointegration of the system and it can be applied regardless of the order of integration (i.e., I(0), I(1), or I(2)) of the series as long as k>=1=d. The Toda Yamamoto approach was used by, among others, Wolde-Rufael (2005, 2006, 2009), Lee (2005), Payne (2010), Bowden and Payne (2009), and Ziramba (2009).

Here, let Y_t be the log (RGDPPC) and E_t be the log (EUPC). Rambaldi and Doran (1996) have explained that the MWALD test used for testing Granger non-causality can be more efficient when using a Seemingly Unrelated Regression (SUR) method. Thus based on Toda and Yamamoto (1995) procedure, the Granger non-causality between economic growth and energy use can be tested using the following VAR system given in equations (1-2):

$$Yt = \alpha 1 + \sum_{i=1}^{k+dmax} \alpha 2i Yt-i + \sum_{i=1}^{k+dmax} \alpha 3i Et-i + \varepsilon 1t \ldots\ldots\ldots (1)$$

$$Et = \beta 1 + \sum_{i=1}^{k+dmax} \beta 2i Yt-i + \sum_{i=1}^{k+dmax} \beta 3i Et-i + \varepsilon 2t \ldots\ldots (2)$$

For example, when using Toda and Yamamoto (1995) approach to test the Granger non-causality from *E* to *Y*, we need to test the H_0: $\alpha 3i = 0$ for all $i \leq k$ in equation 1 and causality from *E* to *Y* can be established through rejecting the null hypothesis stated above. A similar procedure can be used to test the causality from *Y* to *E*, i.e., to test H_0: $\beta_{2i} = 0$ for all $i \leq k$ in equation 2 and causality from *Y* to *E* can be established if $\beta_{2i} \neq 0$ for all $i \leq k$.

3. **Empirical results**

Following Toda and Yamamoto (1995) method, before testing for the non-causality between economic growth and energy use, we need to establish the lag length (k) of the VAR model and the order of integration (dmax) of the variables used in the model. We used Akaiki Information Criterion (AIC) to establish the lag length (k) of the VAR model. According to the AIC, the optimal lag length (k) for the VAR was established at 3, i.e. k=3. For the order of

integration (dmax) of the variables used, the ADF test was used. The ADF results given in Table 1 show that all the variables are integrated of order of one (i.e., *I (1)*).

Table 1

ADF Unit Root Test

(The null hypothesis: Y and E have a unit root)

Country/Period	Variables	Level	First Difference
Jordan (1975-2007)	Y [a]	-2.554 (0)[b]	-4.659***[c] (0)
	E [a]	-3.244 (0)[b]	-6.563***[c] (0)

Notes: [a] Y and E as defined above. [b] Optimal lags according to Schwarz Information Criterion (SIC) are given in parenthesis.
[c] ***, **, and * indicate significanc3e levels of the 1%, 5%, and 10%, respectively.

Table 2 reports Chi-square statistics and the p-values for the purpose of testing the Granger-no causality using Toda-Yamamoto method. The results show that the null hypothesis of Granger-no-causality from economic growth to energy use can be rejected lending support to a unidirectional Granger causality from economic growth to energy use. However, the null hypothesis of Granger-no-causality from energy use to economic growth cannot be rejected.

Table 2

Granger Causality Test Results Based on Toda-Yamamoto Method

Ho:	Lag Length [b] /Var order	MWald Statistics (d.o.f.)	p-value
E ≠> Y [a]	3/4	4.723 (3)	0.1916
Y ≠> E [a]	3/4	6.630 (3)	0.0847* [c]

Notes: [a] Y and E as defined above. [b] Optimal lags are determined according to Akaiki Information Criterion (AIC). Degrees of freedom (d.o.f.) are given in parentheses.
[c] ***, **, and * indicate rejection of the null hypothesis at significance levels of the 1%, 5%, and 10%, respectively.

4. **Conclusion**

Using time series data over the period 1975-2007, this study empirically examines the causal relationship between energy use and economic growth in Jordan using the Granger-no-causality method developed by Toda and Yamamoto (1995). The empirical results give no support to the hypothesis that energy use causes (in the Granger sense) economic growth as it was found by the study of Chontanawat et al. (2008) for Jordan. However, it was economic growth that Granger causes energy use. The results for Jordan support that economic growth promotes energy use which are consistent with those of Ghosh (2002); Oh and Lee (2004); Lise and Van Montfort (2007); Mehrara (2007); Mozumder and Marathe (2007); and Soytas and Sari (2003) who have found evidence of a unidirectional causality running from economic growth to energy use. This suggests that the results lend support to the growth-led energy use hypothesis. This means that economic growth generates a rise in energy use. In this case, energy use is primarily driven by income; therefore, using measures to conserve energy may be feasible without compromising economic growth. The results should, however, be interpreted with cautious due to omission of some variables. It should also be noted that the results may be sensitive to sample size and the choice of the measures that are used for variables used in the study.

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