The Impact of Energy Consumption and Financial Development on Economic Growth in the United States: An ARDL Bounds Testing Approach

Dr. Hung-Ming Wu
Aletheia University No. 32, Zhenli Street, Tamsui Dist., New Taipei City, 25103
Taiwan, R.O.C.

Abstract

This study investigates the impact of energy consumption and financial development on economic growth using neo-classical production function in the case of US. The ARDL (Autoregressive distributed lag) bounds testing approach with additional variables (energy consumption and financial development) is used to investigate cointegration during the period of 1967-2012 in US. The ARDL reveals a cointegration relationship among energy consumption, financial development, capital and economic growth. Energy consumption and financial development reveal short term impacts but no long-term impacts on economic development. Capital has short and long impacts on economic development. Therefore, energy conservation policies can be implemented since energy consumption only has short term effects on economic growth but not long term effects. The result also implies that the US government should encourage the financial sector to develop a new financial policy or system to boost up the process of capitalization to keep going economic growth.

JEL: C5; Q43

Key words: ARDL; energy consumption; financial development; economic growth.

1. Introduction

The impact of energy consumption and financial development on economic growth in the US was explored by using the neo-classical production function. Developed countries such as the US have been asked to take responsibility for environmental protection. The US may be one of world having higher technology to use energy efficiently and has economic growth in the same time. Energy consumption (environment protection) has been a hot issue in recent years. Since 1970’s the relationship between energy consumption and economic growth have been discussed (Kraft and Kraft, 1978). Since then, many studies have discussed the relationship between energy consumption and economic growth, but their results have been inconclusive. Conclusions differ because studies have been performed in different countries, different time period, different models, and different countries’ uniqueness (Ozturk, 2010; Payne, 2010).

Four causal relationships between economic growth and energy consumption have been proposed. The growth hypothesis is that energy Granger causes output, the conservation hypothesis is that output Granger causes energy, the feedback hypothesis is that energy and output Granger cause each other, and the neutrality hypothesis is that energy and output do not Granger cause each other (Payne, 2010). The four hypotheses can be divided into two views: one is that energy consumption affects economic growth, and the other one is that energy consumption does not affect economic growth. If energy consumption does not affect economic growth, energy conservation policy can be used since it may not hurt economic growth. The next question is the size of the effect and the duration of the effect. Sari et al.(2008) applied the ARDL(autoregressive distributed lag) bounds testing approach (proposed by Pesaran et al.(2001)) to find the amount of the effect. The ARDL also can estimate the short run and long run effect. The final question is whether an important variable such as financial development has been excluded.

Financial development has been discussed about affecting economic growth (King & Levine, 1993; Odedokun, 1996; Ang, 2008; Wolde-Rufael, 2009; Shahbaz, et.al, 2013). The reason to put the financial development in the production is that it lets people easy to get loan (cheaper cost) in some items, for example household appliances, mobiles, house, et al. Therefore, it may have a positive effect on economic growth (Mehrara, and Musai 2012).

Therefore, the study adds the important variables (financial development and energy consumption) in neo-classical production function in the research. The study also concern about the utilization of input (capital), since the utilization rate of capital may not be full in every year in the real world (Klein and Su, 1979). To the best of my knowledge, this study is the first empirical study that uses the variables (economic growth, capital, energy consumption, and financial development) with the advanced and the popular model ARDL bounds testing approach (Pesaran et al., 2001)) and the utilization rate of capital to investigate cointegration relationship among these variables in US to find the long run and short run effect.

The research revealed a cointegration relationship among energy consumption, financial development, capital and economic growth. Energy consumption and financial development revealed short term impacts but no long-term impacts on economic development. The capital has short and long impacts on economic development. This implies that energy conservation policies should be implemented because energy conservation policies only have short term effects on economic growth but no long-term effects. Therefore, the US government may continue to promote more investments on energy efficiency research to keep going economic growth.

This paper is organized as follows: Section 1 is introduction, Sections 2 is literature review, Section 3 is data and methodology, and Section 4 is empirical results. The last section is conclusion and policy implications.

2. Literature Review

Many researches examine the relationship between energy consumption and economic growth. According to the literature survey paper of Payne (2010), there are more than one hundred empirical papers doing the research of the relationship between energy consumption and economic growth alone up until 2008 (by publication date). These studies have obtained very different results. That is because they may use the different econometric models, time periods, and countries (Payne, 2010)). The financial development has been focus on having the relationship with economic growth in the recent year (King & Levine, 1993;Odedokun, 1996; Ang, 2008; Wolde-Rufael, 2009; Shahbaz, et.al, 2013). Therefore, this literature review focuses on two major findings of these past studies. One is energy consumption- economic growth nexus and the other one is financial development-economic growth nexus.

2.1 Energy Consumption- Economic Growth Nexus

In the early 1970s, Kraft and Kraft (1978) performed the original study of the energy-growth relationship. They reported a unidirectional causality relationship running from GNP（Gross National Product） to energy consumption but not vice versa. Eden& Hwang (1984) apply Sims' technique and use the updated data US (1947–1979) to reexamine the relationship between energy consumption and GNP. They find that there is no relationship between energy consumption and GNP. Both of these studies used bivariate models, which may lose important variable(s) and obtain biased results.

Stern (1993) uses multivariate VAR model by adding capital and employment variable for 1947-90 data for the USA. He finds that energy consumption Granger causes GDP. Ewing et al. (2007) uses the generalized variance decomposition approach to disaggregate energy consumption. They find that natural gas, coal, and fossil fuel do affect output. Lee& Chien, (2010) use an aggregate production function to examine the dynamic relationship among energy consumption, capital stock, and output in G-7 counties. Variance decompositions also revealed that the effect of energy consumption on output is overestimated when the utilization rate of capital in the US ignored. Therefore, this study also applies the utilization rate of capital in this research.

The drawback of the standard Granger test is that it needs a differencing to variables that are non-stationary. The differencing may remove some important long-run information that is very important for policy makers; the drawback has been solved by cointegration model. Yu &Jin (1992) employ cointegration model and find there is no long run relationship between energy consumption and economic growth in US case. However, bivariate analysis may cause bias because it excludes important variable(s). Stern (2000) use cointegration analysis to extend his previous study (multivariate VAR model; Stern, 1993) in US. He finds that the results are similar to his previous results (energy Granger causes output) and there is a long run relationship between energy and output. In Oh & Lee, (2004), a vector error correction model (VECM) revealed no short term causal relationship between output and energy but identified a long-run causal relationship between output and energy in Korea. A limitation of the VECM model is that all the variables in the VECM model needs to be the same order of integration. Another drawback of the VECM model is that variables must be assigned the same lag-lengths. The ARDL model can avoid these two drawbacks of the VECM model (Umer, 2014).

2.2 Financial Development-Economic Growth nexus

Recent studies have revealed a relationship between financial development and economic growth (King & Levine, 1993; Odedokun, 1996; Ang, 2008; Wolde-Rufael, 2009; Shahbaz, et.al, 2013). King & Levine (1993) argued that, as financial systems improve, innovation and economic growth improve. Odedokun (1996) use the conventional neo-classical production function (adding the financial development variable) model in LDCs (least developed countries) by using annual data for 71 countries. Financial development had a positive effect on economic growth in approximately 85% of these counties. Ang (2008) use the ARDL bounds approach to find that financial development has positive effect on output in Malaysia. In Wolde-Rufael (2009), the Granger causality model (Toda and Yamamoto (1995) procedure) revealed that financial development Granger causes economic growth in Kenya. Shahbaz et.al (2013) use ARDL bounds testing approach and find financial development have positive effect on economic growth in China. Granger causality analysis further revealed a two-way (bidirectional) causal relationship between financial development and economic growth.

Although many studies have investigated the energy consumption- economic growth nexus and the financial development-economic growth nexus, very few studies have examined the relationship among energy consumption, financial development, and economic growth with production function. Therefore, this study performed an in-depth analysis of the impact (both in short run and long run impact) of energy consumption and financial development on economic growth with production function and an advanced methodology-ARDL bound testing procedure for the empirical study of US.

3. Data and Methodology

Recent studies have argued that energy is an important production input (Stern, 1993, 2000; Ghali and El-Sakka, 2004; Lee and Chang, 2008; Lean and Smyth, 2014). Financial development is also considered an important input (Odedokun, 1996; Anwar and Nguyen, 2011; Shahbaz, et.al,, 2013; Shahbaz, et.al, 2014). According to the existing literature, the impact of energy consumption and financial development on economic growth is empirically examined by the following model:

$$\ln y_t = \beta_0 + \beta_1 \ln ku_t + \beta_2 \ln ec_t + \beta_3 \ln fd_t + \mu_t \qquad (1)$$

where y is GDP per capita at constant price(constant 2005 US$) (a proxy for economic growth), ku is capital per capita (Gross fixed capital formation (constant 2005 US$)),which is with full utilization rate, ec is energy consumption in kg of oil equivalent per capita, fd is financial development proxies by real domestic credit to private sector per capita (using Domestic credit to private sector (% of GDP) to multiple by GDP current price, divide by CPI price index and divide by population), μ_t is a stationary error term. All variables are took logarithm (written by ln). All data were obtained from World Development Indicators (WDI, by the World Bank) with the exception of utilization rate of capital, which was obtained from the Board of Governors of the Federal Reserve System (https://research.stlouisfed.org/fred2/). Most empirical studies have focused on the full utilization of capital. However, the calculation for the utilization rate of capital must assume that capital may not be fully utilized every year (Klein and Su, 1979; Lee& Chien, 2010)). Therefore, this study modifies Eq. (1) of the aggregate production function to be as follows:

$$\ln y_t = \beta_0 + \beta_1 \ln k_t + \beta_2 \ln ec_t + \beta_3 \ln fd_t + \mu_t \qquad (2)$$

Where $k_t = \delta * ku_t$ and

δ Is the rate of capacity utilization?

The autoregressive distributed lag model (ARDL) was used to test for cointegration and to estimate long-run and short-run dynamics. The ARDL model has an advantage to handle the variables (the variables may include a mixture of stationary and non-stationary time-series, for example, integrated of order (1) or (0)). Another advantage of the model is that it is easy to implement and interpret since it involves only a single-equation arrangement. Another advantage is that different variables of the model can be assigned different lag-lengths (Pesaran and Shin 1999; Pesaran et al. 2001). In order to find the long run and short run relationship, the dynamic error correction model has been used, which derived by ARDL model. The model is presented as follows:

$$\Delta \ln y_t = \alpha_0 + \sum_{i=1}^{n1}\phi_i \Delta \ln y_{t-i} + \sum_{i=0}^{n2}\varphi_i \Delta \ln k_{t-i} + \sum_{i=0}^{n3}\gamma_i \Delta \ln ec_{t-i} + \sum_{i=0}^{n4}\eta_i \Delta \ln fd_{t-i} + \lambda_1 \ln y_{t-1} + \lambda_2 \ln k_{t-1} + \lambda_3 \ln ec_{t-1} + \lambda_4 \ln fd_{t-1} + \varepsilon_t \quad (3)$$

Where ϕ ,φ,γ and η are short run parameters and λ_1 to λ_4 are long run parameters. To test cointegration, the null hypothesis is set to H_0: $\lambda_1=\lambda_2=\lambda_3=\lambda_4=0$ against the alternative hypothesis H_0 is not true. A rejection of the null hypothesis implies that the model has a long-run (cointegration) relationship. Pesaran et al. (2001) provides the upper bounds and lower bounds on different numbers of variables to be the critical values. The upper bound (UB) is based on the assumption that all variables are I(1) and the lower bound (LB) applies if the series are I(0). An F-statistic above the UB indicates that it has cointegration. An F-statistic below the LB indicates that there is no cointegration. If the F-statistic falls between the UB and LB, the test is inconclusive.

The Akaike Information Criterion (AIC) was used to select the orders of the lags for the specification in the ARDL model. AIC is one of popular model selection criterion. Even though it has a risk of over-fitting the model but I would not under-fit the model. The lag length that minimizes AIC is then selected. After the suitable lag structure for Eq. (3) has been selected, Eq. (3) must be tested to ensure that its error term is serially independent. Then, the bounds test is used to test the model for whether there is a long run relationship between these variables. If a long run (cointergration) relationship is observed, we can estimate the long run model (levels model) and the short run model (conventional error-correction model). If a long run (cointegration) relationship among these variables is identified, all of the first differences of the variables in the Eq. (3) are equal to zero, for example,

$\Delta \ln y_t = \Delta \ln k_t = \Delta \ln ec_t = \Delta \ln fd_t = 0$. And the long run model can be formulated as the following form:

$$\ln y_t = \omega_1 + \omega_2 \ln k_t + \omega_3 \ln ec_t + \omega_4 \ln fd_t + \varepsilon_{1t} \ldots\ldots (4)$$

Where, the long run coefficients $\omega_1 = -\alpha_0/\lambda_1$; $\omega_2 = -\lambda_2/\lambda_1$; $\omega_3 = -\lambda_3/\lambda_1$; $\omega_4 = -\lambda_4/\lambda_1$, and ε_{1t} is the random error. To estimate the short run relationship, the conventional error correction model version model from the ARDL model in Eq. (3) is used as follows:

$$\Delta \ln y_t = \alpha_2 + \sum_{i=1}^{n1}\phi_{2i} \Delta \ln y_{t-i} + \sum_{i=0}^{n2}\varphi_{2i} \Delta \ln k_{t-i} + \sum_{i=0}^{n3}\gamma_{2i} \Delta \ln ec_{t-i} + \sum_{i=0}^{n4}\eta_{2i} \Delta \ln fd_{t-i} + \psi \mathrm{ECM}_{t-1} + \varepsilon_{2t} \ldots\ldots (5)$$

The coefficient of the error correction term (ECM_{t-1}) in Eq. (5) is the speed of adjustment from the short-run to the long-run, which is expected to be negative and statistically significant. The model has been tested by the diagnostic tests that are serial correlation LM test for serial correlation, normality test for normality, autoregressive conditional heteroskedasticity test and white heteroskedasticity test for heteroskedasticity , and Ramsey RESET test for the functional form. Stability tests (cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMSQ)) are also used to test the goodness of fit of the ARDL model.

4. Empirical Results

The ARDL model used for empirical analysis was constructed using Eviews 9 econometric software. Since the ARDL model only can be used in the variables are integrated of I(0) or I(1) (Pesaran et al. 2001), unit root tests have to be used to make sure all the variables are no integrated of I(2) or higher. The study used two popular unit root tests, the augmented Dickey-Fuller (ADF) (Dickey and Fuller, 1979) and Phillips–Perron (PP) (Phillips and Perron, 1988) tests. Table 1 shows the unit root tests results. All variables in the levels are not stationary but all variables in integrated of order 1 or I(1), first difference, are stationary.

The bound test was used to evaluate cointegration. And the result of bound test is shown in Table 2. In the Table 2, the value of k (the number of all variables are k+1) is 3 in the model that the research used. The F-statistics is 7.14 and higher than upper critical bound 5.61(1% significance level), which indicates a long term relationship among economic growth, energy consumption, financial development, and capital during 1967-2012 in US.

Table 1: Unit Root Tests

	ADF test		PP test	
	(t-Statistic)		(adjusted	t-Statistic)
	Level			
Variable	**Constant Without Trend**	**Constant With Trend**	**Constant Without Trend**	**Constant With Trend**
ln y	-1.43	-2.33	-1.62	-1.44
ln k	-1.36	-2.9	-1.08	-2.77
ln ec	-2.24	-2.49	-2.43	-2.41
ln fd	-0.47	-2.43	-0.51	-1.89
	First Difference			
ln y	-5.02*	-5.05*	-4.86 *	-4.93*
ln k	-6.08*	-6.01*	-6.06*	-10.87*
ln ec	-4.59 *	-4.91*	-4.49 *	-4.80*
ln fd	-5.01 *	-4.95*	-0.51 *	-4.97*

Notes: * denotes significance at the 5% level.

Table 2: Results of Bounds Test

F-statistics	k	Significance Level	Bound Critical values	
			I(0)	I(1)
7.14	3	1%	4.29	5.61
		5%	3.23	4.35
		10%	2.72	3.77

The ARDL (5, 1, 1, 5) model is selected by Akaike info criterion (AIC). The model can estimate the coefficients of the long-run relations and the short run relations. Table 3 presents the estimated long run coefficients and the short run coefficients.

The long run coefficient of energy consumption is -0.28 and is not significant (p value is 0.2 which is greater than 5%), all else being constant, which means that conservative energy policy will not affect US economic growth in the long run. The coefficient of financial development is 0.10 and is insignificant (p value is 0.24 which is greater than 5%) in the long run. This indicates that financial development does not affect long term economic growth. The coefficient of capital is 0.57 and is significant (p values is close to 0 which is less than 5%). That is, a 1 per cent increase in capital increases economic growth by approximately 0.57 percent. Table 3 shows the results obtained when the conventional error correction model is used to estimate the short run relationship. The result suggests that the energy consumption has short run impact on economic growth because the coefficient of lag one is positive and significant (p value 0.03 is less than 5%). The coefficient of capital is 0.16, positive and statistically significant. That is, capital positively affects economic growth. The coefficient of financial development also has the expected positive sign and significance at 5%. The coefficient of *ECM* (-0.15) is negative and very significant, which suggests that nearly 15% of any deviation from the long-run equilibrium is corrected within one year.

Diagnostic tests of the model are performed to evaluate serial correlation (serial correlation LM), normality (normality test), heteroskedasticity (autoregressive conditional heteroskedasticity and white heteroskedasticity), and functional form (Ramsey RESET Test) in Table 3. The diagnostic test results suggest that there is no serial correlation, autoregressive conditional heteroskedasticity and white heteroskedasticity at the 5% significance level. The diagnostic test results also reveal normal residual terms. The Ramsey reset test suggests that the model appears well specified.

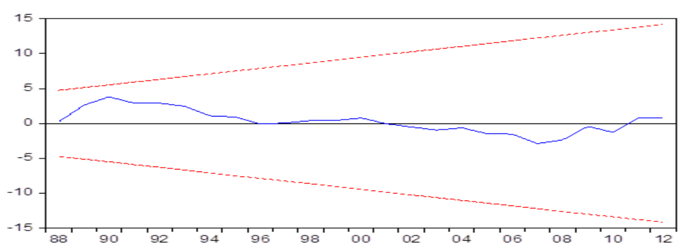
Table 3: Statistical output for long run、 short run model and diagnostic tests

	Long run model coefficients	
Regressor	Coefficient	p-value
constant	7.14	<0.01*
ln k	0.57	<0.01*
ln ec	-0.28	0.20
ln fd	0.1	0.24
	Short run model coefficients	
Regressor	Coefficient	p-value
Δ*ln k*	0.16	<0.01*
Δ*ln ec*	0.07	0.32
Δ*ln ec(-1)*	0.2	0.03*
Δ*ln fd*	0.06	0.01*
ECM	-0.15	<0.01*
Diagnostic tests (p-value)		
Serial Correlation LM (0.09)		
Normality Test (0.66)		
ARCH Test (0.18)		
Heteroscedisticity Test (0.08)		
Ramsey RESET Test (0.1)		

Notes: * denotes significance at the 5% level.

The stability of the estimated model was tested by calculating the cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMSQ). Both these plots in Figs. 1 and 2 are in the critical bounds at 5% significance level, which indicates that the estimated model is stable in the research period.

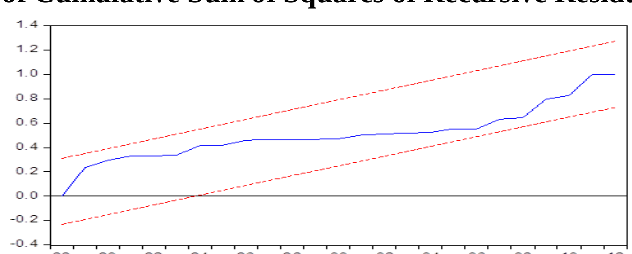
Plot of Cumulative Sum of Recursive Residuals



The straight lines represent critical bounds at 5% significance level

Figure 1: CUSUM Plots for Stability Tests

Plot of Cumulative Sum of Squares of Recursive Residuals



The straight lines represent critical bounds at 5% significance level.

Figure 2: CUSUMSQ Plots for Stability Test

5. Conclusions and policy implications

This study examined the impact of energy consumption, financial development, and capital on US economic growth during 1967-2012.

The ARDL bounds testing model was used in neoclassical production function to identify short-term and long-term relationships among these variables. The production function revealed a large difference from previous research. That is, the important variable "capital" has been concerned about that capital is not fully utilized each year. The novel contribution of the study is the empirical analysis of the impact of energy consumption and financial development on US economic growth with the utilization of capital in production function by ARDL bounds testing model.

The analysis revealed a cointegration relationship among energy consumption, financial development, capital, and economic growth. The test suggests that there is a positive impact of energy consumption on economic growth only in short run but not in the long run. In the long run, it follows the neutrality hypothesis (Payne, 2010) in the US empirical study. This implies that energy conservation policy will not have long-term negative effects on U.S. economic growth. The US may continue to develop the energy efficiency technologies to maintain the economic growth of US in the long run. Financial development positively affects economic growth in the short term but not in the long term. Therefore, the US government should encourage the financial sector to develop a new financial policy or system to boost up the process of capitalization and to produce a sound energy infrastructure. Financial development would then have both long-term and short-term positive effects on economic growth. Capital positively affects economic growth and is a very important input of economic growth both in short run and in long run. The capital has a respected result and follows the production theory. This implies that the US government should encourage people to invest more in the capital to maintain the US economic growth.

Further studies are needed to compare cross sectional data. Time series data are also needed for policy analyses of a single country. This study used time series data (annual data) for analysis of U.S. policy. However, because of the degree of freedom, time series data cannot include all important variables (for example, export, government spending, and tourism and so on) which may affect the economic development (Smyth & Narayan, 2014)). To increase the number of important variables, future studies may use high frequency data if all the data are available. For example, industrial production index monthly data may be used as an alternative to GDP.

References

Abosedra, S., Baghestani, H., 1991. New evidence on the causal relationship between United States energy consumption and gross national product. Journal of Energy and Development 14 (2), 285-292.

Ang, J. B. (2008). What are the mechanisms linking financial development and economic growth in Malaysia?. Economic Modelling, 25(1), 38-53.

Anwar, S., & Nguyen, L. P. (2011). Financial development and economic growth in Vietnam. Journal of Economics and Finance, 35(3), 348-360.

Cheng, B., 1995. An investigation of cointegration and causality between energy consumption and economic growth. Journal of Energy Development 21, 73–84.

Denison, E.,1985. Trends in American Economic Growth, 1929–1982. Brookings Institution. Washington, DC.

Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. Journal of the American statistical association, 74(366a), 427-431.

Eden, S. H., & Hwang, B. K. (1984). The relationship between energy and GNP: further results. Energy Economics, 6(3), 186-190.

Ewing, B. T., Sari, R., & Soytas, U. (2007). Disaggregate energy consumption and industrial output in the United States. Energy Policy, 35(2), 1274-1281.

Ghali, K.H., El-Sakka, M.I.T., 2004. Energy use and output growth in Canada: a multivariate cointegration analysis.Energy Economics 26 (2), 225–238.

King, R. G., & Levine, R. (1993). Finance, entrepreneurship and growth. Journal of Monetary economics, 32(3), 513-542.

Klein, L. R., & Su, V. (1979). Direct estimates of unemployment rate and capacity utilization in macroeconometric models. *International Economic Review*, 725-740.

Kraft, J., Kraft, A., 1978. Relationships between energy and GNP. Journal of Energy and Development 3, 401–403.

Le, Kim-Song and Hassan, Kamrul and Gasbarro, Dominic and Cullen, Grant, The Relation between Financial Development, Energy Consumption and Economic Growth: Empirical Evidence for the United States (August 20, 2014). 27th Australasian Finance and Banking Conference 2014 Paper. Available at SSRN: http://ssrn.com/abstract=2484279 or http://dx.doi.org/10.2139/ssrn.2484279

Lean, H. H., & Smyth, R. (2014). Disaggregated energy demand by fuel type and economic growth in Malaysia. Applied Energy, 132, 168-177.

Lee, C. C., & Chang, C. P. (2008). Energy consumption and economic growth in Asian economies: a more comprehensive analysis using panel data. Resource and energy Economics, 30(1), 50-65.

Lee, C. C., & Chien, M. S. (2010). Dynamic modelling of energy consumption, capital stock, and real income in G-7 countries. Energy Economics, 32(3), 564-581.

Masih, A. M., & Masih, R. (1996). Energy consumption, real income and temporal causality: results from a multi-country study based on cointegration and error-correction modelling techniques. Energy economics, 18(3), 165-183.

Mehrara, M., & Musai, M. (2012). Energy consumption, financial development and economic growth: an ARDL approach for the case of Iran. *International Journal of Business and Behavioral Sciences*, *2*(6), 92-99.

Odedokun, M. O. (1996). Alternative econometric approaches for analysing the role of the financial sector in economic growth: Time-series evidence from LDCs. Journal of Development Economics, 50(1), 119-146.

Oh, W., & Lee, K. (2004). Energy consumption and economic growth in Korea: testing the causality relation. Journal of Policy Modeling, 26(8), 973-981.

Ozturk, I. (2010). A literature survey on energy–growth nexus. *Energy policy,38*(1), 340-349.

Payne, J., 2010. A survey of the electricity consumption-growth literature. Applied Energy 87,3723-3731.

Pesaran, M.H., Shin, Y., 1999. An autoregressive distributed lag modeling approach to cointegration analysis. In: Strom, S. (Ed.), Econometrics and Economic Theory in the 20th Century.

Pesaran, M.H., Shin, Y., Smith, R.J., 2001. Bounds testing approaches to the analysis of level relationships. Journal of Applied Econometrics 16, 289–326

Phillips, P.C.B., Perron, P., 1988. Testing for a unit root. Biometrica 75, 335-346.

Sari, R., Ewing, B. T., & Soytas, U. (2008). The relationship between disaggregate energy consumption and industrial production in the United States: an ARDL approach. Energy Economics, 30(5), 2302-2313.

Shahbaz, M., Arouri, M., & Teulon, F. (2014). Short-and long-run relationships between natural gas consumption and economic growth: Evidence from Pakistan. Economic Modelling, 41, 219-226.

Shahbaz, M., Khan, S., & Tahir, M. I. (2013). The dynamic links between energy consumption, economic growth, financial development and trade in China: fresh evidence from multivariate framework analysis. Energy Economics, 40, 8-21.

Shahbaz, M., Rehman, I. U., & Muzaffar, A. T. (2014). Re-Visiting Financial Development and Economic Growth Nexus: The Role of Capitalization in Bangladesh. South African Journal of Economics.

Shahbaz, M., Zeshan, M., & Afza, T. (2012). Is energy consumption effective to spur economic growth in Pakistan? New evidence from bounds test to level relationships and Granger causality tests. *Economic Modelling*, *29*(6), 2310-2319.

Schumpter, J. A., 1934. Theory of economic development. Cambridge, MA: Harvard U, Press.

Solow, R., 1978. Resources and economic growth. American Economic Review 22, 5–11.

Soytas, U., & Sari, R. (2006). Energy consumption and income in G-7 countries. Journal of Policy Modeling, 28(7), 739-750.

Smyth, R., & Narayan, P. K. (2014). Applied econometrics and implications for energy economics research. Energy Economics.

Stern, D. I. (1993). Energy and economic growth in the USA: a multivariate approach. Energy Economics, 15(2), 137-150.

Stern, D. I. (2000). A multivariate cointegration analysis of the role of energy in the US macroeconomy. Energy Economics, 22(2), 267-283.

Thoma, M., 2004. Electrical energy usage over the business cycle. Energy Economics 26 (3), 463-485.

Toda, H. Y., & Yamamoto, T. (1995). Statistical inference in vector autoregressions with possibly integrated processes. Journal of econometrics, 66(1), 225-250.

Umer, Faiza.(2014) "Impact of Trade Openness on Economic Growth of Pakistan: An ARDL Approach.",Journal of Business & Economic Policy, 1(1), 2014

Wolde-Rufael, Y. (2009). Re-examining the financial development and economic growth nexus in Kenya. Economic Modelling, 26(6), 1140-1146.

Yu, E.S.H. and Jin, J.C. (1992), “Cointegration tests of energy consumption, income, and employment”, Resources and Energy, Vol. 14, pp. 259-66.