Encompassing Of Nested and Non-nested Models:Energy-Growth Models

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Encompassing Of Nested and Non-Nested Models: Energy-Growth Models

By
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Abstract:

Whether models are nested or non-nested it is important to be able to compare them and evaluate their comparative results. In this study three energy-growth models by Kraft and Kraft (1978) and Dantama, Zakari, Inuwa (2011) has used, and third model has modified by joining and adding dummies in it. By using these three models we have tested them for non-nested and nested encompassing through Cox test and F-test respectively.

Key words: Nested, Non-nested, Encompassing, Energy Growth

JEL Classification: *O43, C1, C5*

1. INTRODUCTION

Encompassing

Whether models are nested or non-nested it is important to be able to compare them and evaluate their comparative results, and "The encompassing principle is concerned with the ability of a model to account for the behaviour of others, or to explain the behaviour of relevant characteristics of other models." (Mizon (1984)). A model M1 encompasses another model M2 if M1 can account for results obtained from M2: In other words, anything that can be done using M2 can be done equally well using M1; and so once M1 is available M2 has nothing further to offer.

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Background

Mizon and Richard (1986), Hendry and Richard (1989), Wooldridge (1990), and Lu and Mizon (1996) focus on variance and parameter encompassing. Mizon and Richard (1986) consider a wide range of possible encompassing test statistics and show that Cox-type tests of non-nested hypotheses are tests of variance encompassing. Hendry and Richard (1989) summarize the encompassing literature to date, generalize certain characteristics of encompassing, and consider various differences to encompassing when the models are dynamic. Wooldridge (1990) derives a conditional mean encompassing test and compares it to the Cox and Mizon-Richard tests. In the study of Kenneth D. West (2000) considered regression based tests for encompassing, when none of the models under consideration encompasses all the other models.

Nested and Non-Nested Models

M1 is nested within M2 if and only if M1 ⊆ M2, Whenever M1 and M2 do not satisfy the conditions in this definition they are said to be non-nested.

M1: $\boldsymbol{Y = X\beta + \varepsilon}$

M2: $\boldsymbol{Y = Z\gamma + u}$

} **non nested**

M3: $\boldsymbol{Y = X\beta + Z\gamma + W\delta + e}$ **-----------** ***both M2 and M2 (Nested)***

Objective

- To test the models for encompassing

After the introduction section, the chapter of literature review has explained, then in second section methodology of the project has given that will be used to fulfill our objective. After that result and discussion chapter, that explains the encompassing concept and finally conclusion followed by references and appendix.

2. LITERATURE REVIEW

In the literature there are lots of model that are based on energy growth model, different authers has used different variables to explain the effect of energy consumption on the growth and has used different types of models like i.e. by using Cobb Douglas production function. Qayyum (2007), Akram (2011), Zahid (2008), Kraft and Kraft (1978), Bekhet and Yusop (2009), Chang and Lai (1997), Asafu-Adjaye (2000), Rufael (2004), Lee and Chang (2005), Siddiqui (2004), Chontanawat (2008), Hou (2009), Bhusal (2010), Pradhan (2010). All these studies concluded diverse results regarding energy (oil) consumption and growth.

The initiative to word energy-growth model was first established in the influential paper of Kraft and Kraft (1978), with the application of a standard form of Granger causality analysis, which presented evidence to sustain a unidirectional long run relationship running from GDP to energy consumption for the USA over the 1947-74 periods. This study recommends that government could follow the energy conservation policies.

Mizon and Richard (1986), Hendry and Richard (1989), Wooldridge (1990), and Lu and Mizon (1996) focus on variance and parameter encompassing. Mizon and Richard (1986) consider a wide range of possible encompassing test statistics and show that Cox-type tests of non-nested hypotheses are tests of variance encompassing. Hendry and Richard (1989) summarize the encompassing literature to date, generalize certain aspects of encompassing, and consider various distinctions to encompassing when the models are dynamic. Wooldridge (1990) derives a conditional mean encompassing test and compares it to the Cox and Mizon-Richard tests. In the study of Kenneth D. West (2000) considered regression-based tests for encompassing, when none of the models under consideration encompasses all the other models.

3. METHODOLOGY

For testing the encompassing of models we have used non-nested and nested models of energy–growth.

Testing the Energy-growth models

Following three models has selected to test for nested and non-nested encompassing.

Model 1: *GDP = f (GFCF, LF, EC)*

Kraft and Kraft (1978)

non-nested models

MODEL 2: *GDP = f (TOC, TEC, TCC)*

Dantama, Zakari, Inuwa (2011)

Nested models

MODEL 3*: GDP = f (GFCF, LF, TOC, TEC, TCC, OP, D)*

Where;

GDP = Gross domestic product, real data of GDP taken as the proxy of economic growth.

GFCF = Gross fixed capital formation divided by GDP is used as the proxy of the capital stock (K) as many paper has used this proxy for capital stock (K), Lee and Chang (2005)

LF = Labor force, EC = Energy Consumption

TOC = Total oil consumption of Pakistan.

TEC = Total Power consumption of Pakistan.

TCC = Total coal consumption of Pakistan.

OP = Domestic oil price of Pakistan.

D_t = Dummy variable for in cooperating the effect of oil prices shocks to Pakistan's economy.

Unit Root Test:

Dickey and Fuller (1979, 1981) gives one of the generally used methods known as Augmented Dickey Fuller (ADF) test of identifying the order of integration I(d) of variables whether the time series data are stationary or not. Following is the general form of Augmented Dickey Fuller test that will be used to check the stationary of series.

$$\Delta X_t = \alpha + \beta t + \varphi X_{t-1} + \theta_1 \Delta X_{t-1} + \theta_2 \Delta X_{t-2} \ldots\ldots\ldots \theta_p \Delta X_{t-p} + \varepsilon_t$$

Where, X_t denotes the time series variable to be tested, used in model. t is time period, Δ is first difference and φ is root of equation. βt is deterministic time trend of the series and α denotes intercept. The numbers of augmented lags (p) determined by the dropping the last lag until we get significant lag. The Augmented Dickey Fuller unit root concept is illustrated through equation ΔX_t

$= (\rho\text{-}1)\ X_{t-1} + \varepsilon_t$, Where, $(\rho\text{-}1)$ can be equal to φ, if $\rho = 1$ so series has the unit root, so root of equation is $\varphi = 0$.

$$\begin{cases} \text{if } \rho = 0 \quad \text{OR} \quad \text{if } \rho = 1 \\ \varphi = (\rho - 1) = 0 - 1 = -1 < 0 \\ \varphi = (\rho - 1) = 1 - 1 = 0 \end{cases}$$

The augmented dickey fuller test can be formulated such as:

a) When the time series is flat or have no any trend then it can be expressed as:

$$\Delta X_t = \varphi X_{t-1} + \theta_1 \Delta X_{t-1} + \theta_2 \Delta X_{t-2} \ldots\ldots\ldots \theta_p \Delta X_{t-p} + \varepsilon_t \quad \therefore \varphi = (\rho - 1)$$

The standard t test does not fellows the normal distribution so McKinnon (1991, 1996) provide the critical values to test following hypothesis. ADF hypothesis fellow the left hand tailed test.

H_0: $\varphi = 0$ (the series is non stationary)

H_1: $\varphi < 0$ (the series is stationary)

b) When the time series is smooth but slow movement around non zero figure, it can be expressed as fellows by including intercept α but no time trend.

$$\Delta X_t = \alpha + \varphi X_{t-1} + \theta_1 \Delta X_{t-1} + \theta_2 \Delta X_{t-2} \ldots\ldots\ldots \theta_p \Delta X_{t-p} + \varepsilon_t$$

Again, the numbers of augmented lags (p) determined by the dropping the last lag until we get significant lag. Hypothesis is left tailed so:

H_0: $\varphi = 0$ (the series is non stationary)

H_1: $\varphi < 0$ (the series is stationary)

c) If the time series data has trend in it and move along the trend line so it can be showed as follows:

$$\Delta X_t = \alpha + \beta t + \varphi X_{t-1} + \theta_1 \Delta X_{t-1} + \theta_2 \Delta X_{t-2} \ldots\ldots\ldots \theta_p \Delta X_{t-p} + \varepsilon_t$$

Where, βt is deterministic trend term in model. In this equation there is intercept and trend term in it. Now the hypothesis will test the whether the data is trend stationary not.

H_0: φ = 0 (the series will be stationary after differencing)

H_1: φ < 0 (the series is time trend stationary and series should be examine with time trend other then differencing it)

Encompassing tests for non-nested models

For testing the non-nested models we used the cox test, *Cox's method* based on maximum likelihood procedures. As an alternative to the J-Test, there is the Cox Test for testing non-nested hypotheses:

H0: Model I: GDP = f (GFCF, LF, EC)

Ha: MODEL 2: GDP = f (TOC, TEC, TCC)

By using following formula:

$$q = \frac{C_{01}}{\sqrt{Var(C_{01})}}$$

For nested model encompasses:

We have used F statistics to test the restriction applied on the model. To test the hypothesis F test is:

$$F = \frac{RSS_R - RSS_{UR} / \text{no. of restrictions}}{RSS_{UR} / n-k}$$

Sources of Data

Data on all variables has taken in context of Pakistan. The sources of data are given below:

I. GDP- Gross Domestic Product- real GDP is available in million rupees at economic survey of Pakistan publish by federal bureau of statistics, in the base year of 1999-2000.

II. K-Gross Fixed Capital Formation- as it self-capital stock data is not available so proxy of Gross Fixed Capital Formation variable has used. Data is his taken in million rupees collected from the economic survey of Pakistan publishes by ministry finance. Having same base year 1999-2000.

III. Labor force-(L) in million numbers from economic survey of Pakistan (ministry of finance).

IV. OP- petrol price of Pakistan taken from different issues of statistical energy year book.

V. TOC, TEC and TCC's data taken from world development index.

4. RESULT AND DISCUSSIONS

In previous chapter we have discussed our methodology, now in this chapter we are going to use above methodology to analysis our data for all four models described above, this chapter comprises of main findings and discussion. That includes results of unit root by Augmented Dickey Fuller test (1979), then the non-nested and nested models has been tested, whether they encompasses the model or not.

Results of Unit Root Test

All data has been transformed into logarithm form. Augmented Dickey Fuller test has applied on the all eight variables. Before applying the ADF test, graphs of series has drawn to examine the pattern of series and present in the Figures 1 to 8. It can be seen from the all figures that there is trend in the series, as graph trended up ward with the time passes. So the time trend will be included in the model. Intercept is also included in the model because by examining the figures of series it can be noticed that data doesn't fluctuate around the zero mean. The average of sample is also not zero so that's why intercept will be included. These are only assumptions to check that these are true or not that data is stationary or non-stationary.

Figure 1: Real GDP of Pakistan

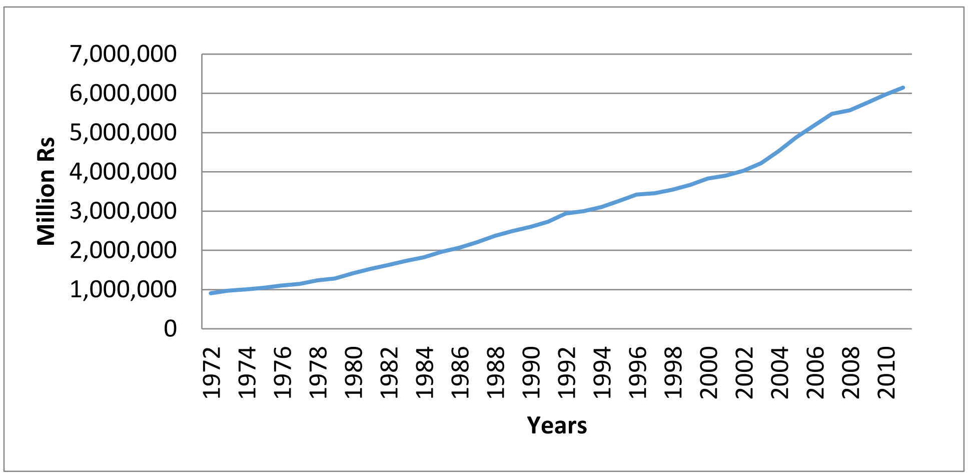

Figure 2: Capital Stock of Pakistan

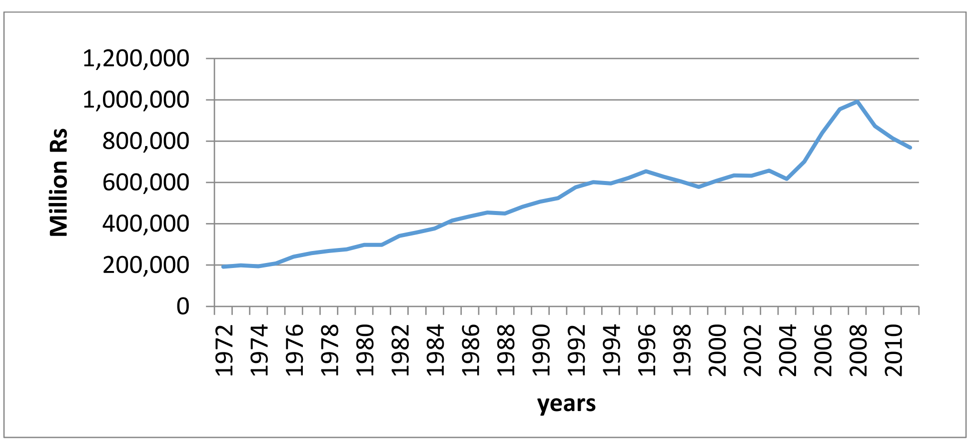

Figure 3: Labor Force of Pakistan

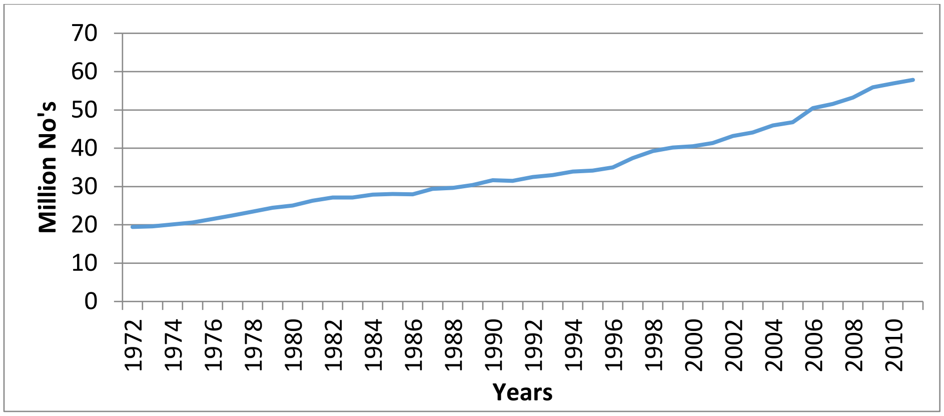

Figure 4: Total Oil Consumption of Pakistan

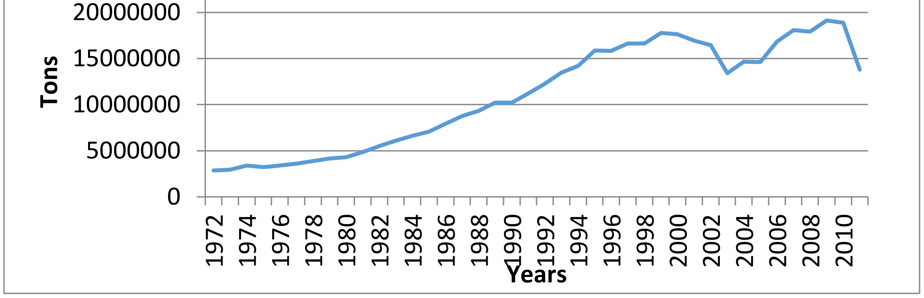

Figure 5: Total Power Consumption of Pakistan

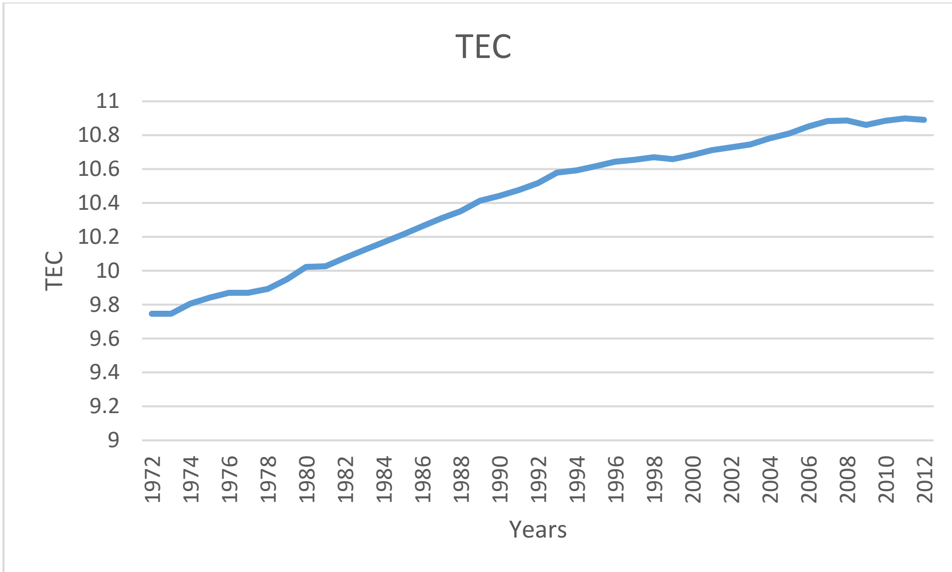

Figure 6: Total Coal Consumption of Pakistan

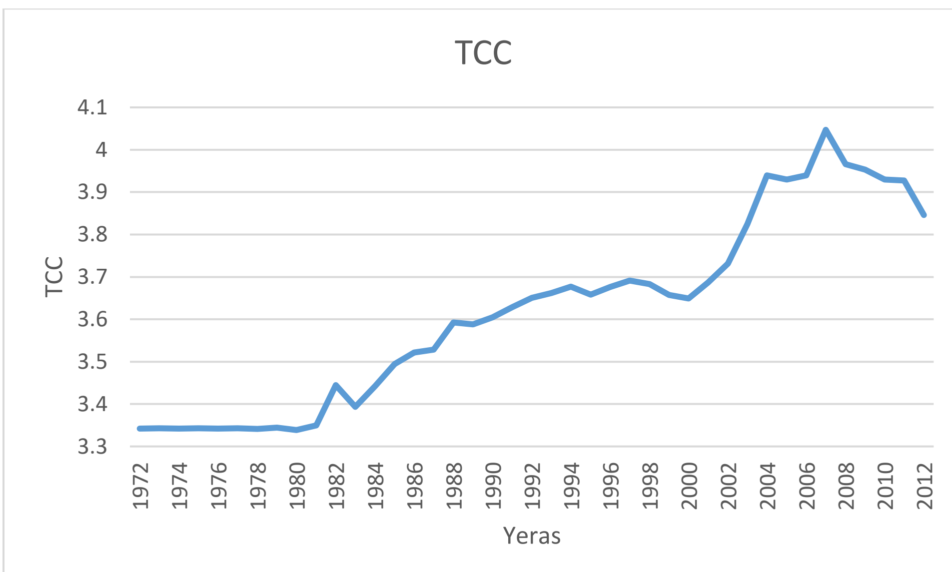

Table 1: Unit Root Test of Augmented Dickey Fuller (Annual Data (T=41))

Level				
Variable	**Deterministic**	**Lags**	**ADF tau-stat**	**Outcome**
LY	Intercept	0	-2.48	I(1)
LTOC	Intercept	0	-2.34	I(1)
LK	Intercept	0	-2.05	I(1)
LLF	Intercept and trend	0	-1.58	I(1)
LTEC	Intercept	0	-2.54	I(1)
LTCC	Intercept and trend	0	-1.98	I(1)
First Difference				
Variable	**Deterministic**	**Lags**	**ADF tau-stat**	**Outcome**
ΔLY	Intercept	0	-4.40	I(0)
ΔLTOC	Intercept and trend	0	-4.41	I(0)
ΔLK	Intercept	0	-3.99	I(0)
ΔLLF	Intercept	0	-6.48	I(0)
ΔLTEC	Intercept and trend	0	-5.82	I(0)
ΔLTCC	Intercept	0	-5.61	I(0)

First, the equation of ADF (with drift and time trend in the model) has estimated, for all the variables. At first, unit root has tested at level or without differencing the data. The results are present in the Table 1. It can be seen from the Table that at level, variables are not stationary. So LY, LL, LP, LTOC, LTEC, LK, and LTCC are stationary at first difference. Therefore, all variables are integrated of order one, I (1).

Non-Nested Encompassing

Model I: $GDP = f\,(GFCF, LF, EC)$

First the energy growth model of Kraft and Kraft (1978) model 1 has estimated as given below, and tested through different diagnostics tests.

$$GDP = +1.725 + 0.6061*GFCF + 0.7867*LF + 0.03614*energy + 0.009089*Trend$$

(SE) (0.238) (0.0575) (0.156) (0.0255) (0.00293)

In the above model according to t- stat given in the appendix table, all variables show significant impact on GDP except LF ,as LF is not so efficient to influence the GDP significantly so it has insignificant impact.

The diagnostics tests has passed on the model which are given below:

Table: 02

AR 1-2 test:	F(2,34)	= 9.3033 [0.0006]**	ARCH 1-1 test:	F(1,39)	= 0.51233 [0.4784]
Normality test:	Chi^2(2)	= 0.14221 [0.9314]	Hetero test:	F(8,32)	= 1.6834 [0.1409]
Hetero-X test:	F(14,26)	= 1.8893 [0.0779]	RESET23 test:	F(2,34)	= 13.047 [0.0001]**

According to the test statistics given above there is no problem of hetero and non-normality but the test statistics of AR test shows that there is the problem of autocorrelation in the model.

MODEL 2: $GDP = f\,(TOC, TEC, TCC)$

The model of Dantama, Zakari, Inuwa (2011) has estimated through OLS given below:

$$GDP = -0.5794 + 0.01*Trend - 0.2355*TOC + 0.8188*TEC + 0.02958*TCC$$

(SE) (0.181) (0.00153) (0.0725) (0.0797) (0.0644)

In the above model according to t- stat given in the appendix table, all variables show significant impact on GDP except TOC, which is showing negative impact on GDP and also it is insignificant that is given in the appendix Table, that is against the theory, as oil consumption is major part of energy consumption in Pakistan, it cannot be negative and has insignificant impact on GDP.

The diagnostics tests has passed on the model which are given below:

Table: 03

AR 1-2 test:	F(2,34) = 25.045 [0.0000]**	ARCH 1-1 test:	F(1,39) = 3.5778 [0.0660]
Normality test:	Chi^2(2) = 5.4849 [0.0644]	Hetero test:	F(8,32) = 1.0000 [0.4551]
Hetero-X test:	F(14,26) = 1.5299 [0.1689]	RESET23 test:	F(2,34) = 33.336 [0.0000]**

According to the test statistics given above there is no problem of hetero and non-normality but the test statistics of AR test shows that there is the problem of autocorrelation in the model.

Tests of non-nested encompassing

The both models 1 and 2 are tested for non-nested encompassing through following tests.

Table: 04

Test	**Model 1 vs. Model 2**	**Model 2 vs. Model 1**
Cox	N(0,1) = -9.940 [0.0000]**	N(0,1) = -8.106 [0.0000]**
Ericsson IV	N(0,1) = 5.155 [0.0000]**	N(0,1) = 4.691 [0.0000]**
Sargan	Chi^2(3) = 29.234 [0.0000]**	Chi^2(3) = 27.592 [0.0000]**
Joint Model	F(3,34) = 42.661 [0.0000]**	F(3,34) = 33.240 [0.0000]**

The Cox test is alternative to J test foe testing the non-nested models.

Cox's test procedure uses a test statistic that that is distribution N(0,1), Cox statistic for testing the hypothesis that model 1 has the correct set of regressors and that model 2 has not, can be represented as:

H0: Model I: GDP = f (GFCF, LF, EC)

Ha: MODEL 2: GDP = f (TOC, TEC, TCC)

Hypothesis will be tested through following formula of Cox test.

$$q = \frac{C_{01}}{\sqrt{Var(C_{01})}}$$

According to test statistic of Cox test it can be said that both model 1 and model 2 has correct regressors to explain GDP, in term of each other's. Other tests Ericsson IV **and** Sargan also conclude the same results.

NESTED ENCOMPASSING

Model 3: *GDP = f (GFCF, LF, TOC, TEC, TCC, Dummy)*

Previous both models ***Model 1*** and ***Model 2*** and joint in single equation and also dummy variable has added in the model to capture the effect the breaks in the data.

$$GDP = +\ 0.28 + 0.14{*}TOC + 0.39{*}TEC + 0.03{*}TCC + 0.03{*}GFCF + 0.47{*}LF - 0.05{*}EC - 0.07{*}D_{2007}$$

(SE) (0.21) (0.05) (0.051) (0.033) (0.05) (0.08) (0.016) (0.018)

In the Model 3, full model, has estimated by OLS, it is fond that all variables have significant impact on the GDP except GFCF and TCC, can be seen through t statistics given in the appendix Table 4, as TOC and LF were showing insignificant impact on GDP in previous restricted models, and also TOC have negative relationship with GDP that is against the theory, so in full model 3 it showing significant positive relationship with GDP. As there is sudden jump in the data series of the TCC, so dummy variable for year 2000 and 2007 has added in the model to capture the effect of break in the model, dummy 2007 showed insignificant impact so it has been removed from the model, and retained only 2000 dummy.

If we examine the diagnostics tests of model 3, there is no problem of autocorrelation as value of test statistics given in appendix table, accepting the null hypothesis that there is no autocorrelation, also the JB test shows that data is normal, the CUSUM and CUMSUM square graphs are also with in the two bands of error that showing mean and variance stability of model.

Encompass tests:

For testing whether full model encompass the previous two models or not we have applied restrictions on the model 3 and tested through the ***F test*** as below.

H0: GFCF = LF = EC = 0 OR Model 1 = 0

H_A: Model 3 ≠ 0 or joint model 3 is better than reduced form model 1

$$F_{cal} = 15.58\ (0.00)$$

$$F_{tab} = 3.23$$

So Ho is rejected as $\boldsymbol{F_{cal}} > F_{tab}$. So full model 3 is better than restricted model 1, and variables of model1 have significant impact on GDP

H0: TOC = TEC = TCC = 0   OR   Model 2 = 0

H_A: Model 3 ≠ 0 or joint model 3 is better than reduced form model 2

$$\boldsymbol{F_{cal}} = 48.14\ (0.00)$$

$$F_{tab} = 3.23$$

as $\boldsymbol{F_{cal}} > F_{tab}$. So full model 3 is better than restricted model 2, and variables of model 2 have significant impact on GDP.

So both restrictions has tested and concluded that all variables in model 3 can explain better the aspects of previous both, we don't need to estimate them separately, but reverse it not true.

CONCLUSION

In this study three energy-growth models by Kraft and Kraft (1978) and Dantama, Zakari, Inuwa (2011) has used, and third model has modified by joining and adding dummies in it. By using these three models we have tested them for non-nested and nested encompassing through Cox test and F-test respectively. And found that in the case of non-nested regressors in both models can explain the GDP well. And in case of nested model or full model 3, it is concluded that model 3 encompasses the model 1 and model 2.

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APPENDIX

Table: Model 1, Modelling GDP by OLS

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	2.74350	0.4390	6.25	0.0000	0.5203
GFCF	0.239149	0.06159	3.88	0.0004	0.2952
LF	0.171146	0.1877	0.912	0.3678	0.0226
EC	0.266044	0.07023	3.79	0.0006	0.2850
Trend	0.00908947	0.002935	3.10	0.0038	0.2104

sigma	0.0116193	RSS	0.00486025598
R^2	0.998152	F(4,36) =	4861 [0.000]**
Adj.R^2	0.997947	log-likelihood	127.148
no. of observations	41	no. of parameters	5
mean(GDP)	6.41649	se(GDP)	0.256422

Table: EQ(2) Modelling GDP by OLS

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	2.56641	0.4972	5.16	0.0000	0.4253
Trend	0.0100050	0.001531	6.53	0.0000	0.5426
TOC	0.0442934	0.06560	0.675	0.5038	0.0125
TEC	0.305267	0.09574	3.19	0.0030	0.2202
TCC	0.0416066	0.04418	0.942	0.3526	0.0240

sigma	0.0141542	RSS	0.00721224435
R^2	0.997258	F(4,36) =	3273 [0.000]**
Adj.R^2	0.996953	log-likelihood	119.057
no. of observations	41	no. of parameters	5
mean(GDP)	6.41649	se(GDP)	0.256422

MODEL 3

Dependent Variable: GDP
Method: Least Squares
Sample: 1972 2012
Included observations: 41

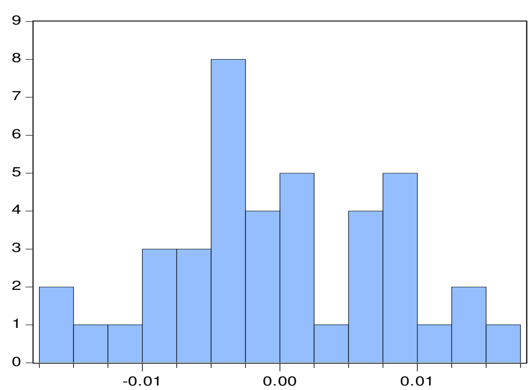
Variable	Coefficient	Std. Error	t-Statistic	Prob.
GFCF	0.035534	0.049364	0.719834	0.4767
LF	0.475658	0.087652	5.426696	0.0000
TCC	0.034159	0.033356	1.024090	0.3132
TEC	0.393854	0.051256	7.684038	0.0000
TOC	0.148554	0.054692	2.716178	0.0104
D2000	0.007611	0.001852	4.109085	0.0002
C	0.284966	0.211216	1.349167	0.1865
EC	-0.053350	0.016327	-3.267633	0.0025

R-squared	0.998992	Mean dependent var	6.416491
Adjusted R-squared	0.998778	S.D. dependent var	0.256422
S.E. of regression	0.008965	Akaike info criterion	-6.417854
Sum squared resid	0.002652	Schwarz criterion	-6.083498
Log likelihood	139.5660	Hannan-Quinn criter.	-6.296100
F-statistic	4670.439	Durbin-Watson stat	2.125126
Prob(F-statistic)	0.000000		

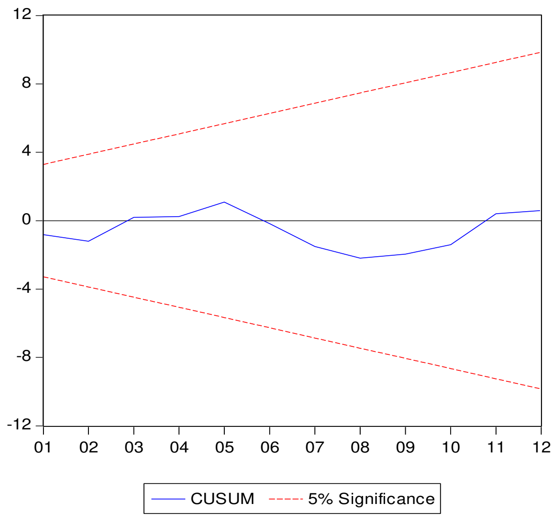
Breusch-Godfrey Serial Correlation LM Test:

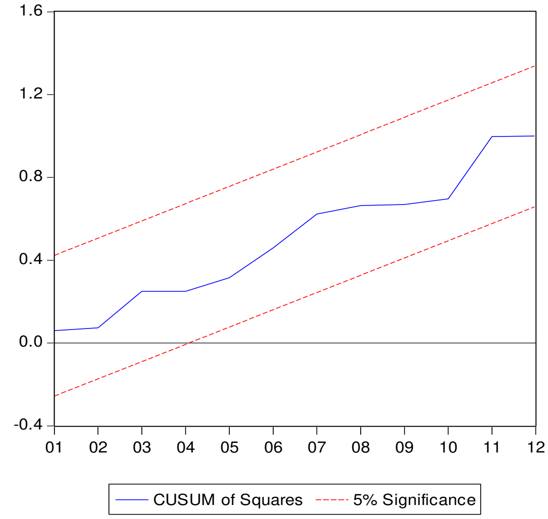
F-statistic	1.502283	Prob. F(2,31)	0.2384
Obs*R-squared	3.622666	Prob. Chi-Square(2)	0.1634

JARQUE-BERA NORMALITY TEST



Series: Residuals	
Sample 1972 2012	
Observations 41	
Mean	-2.20e-15
Median	-0.000398
Maximum	0.017338
Minimum	-0.015157
Std. Dev.	0.008143
Skewness	0.095662
Kurtosis	2.298016
Jarque-Bera	0.904367
Probability	0.636237





RESTRICTION ON GFCF, LF and ENERGY

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	15.58275	(3, 33)	0.0000
Chi-square	46.74826	3	0.0000

RESTRICTION ON TOC, TEC and TCC

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	48.14456	(3, 33)	0.0000
Chi-square	144.4337	3	0.0000