ENERGY–GDP RELATIONSHIP: A CAUSAL ANALYSIS FOR THE FIVE COUNTRIES OF SOUTH ASIA

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Abstract

We investigate the causal relationship between GDP and different types of energy consumption for the five South Asian Countries; Pakistan, India, Sri Lanka, Bangladesh and Nepal by using Error Correction Model and Toda and Yamamoto(1995) approach. For Pakistan evidence shows that there is unidirectional Granger causality running from coal to GDP, and unidirectional Granger causality running from GDP to electricity consumption and total energy consumption. For India no causality in either direction between GDP and different energy consumption is detected. For Sri Lanka there is unidirectional Granger causality running from GDP to electricity consumption and total energy consumption. For Bangladesh unidirectional Granger causality is detected from GDP to electricity consumption and from gas consumption to GDP. For Nepal causal direction is from petroleum to GDP.

JEL codes: C5, D12, O53

Key words: Economic Growth, Granger Causality, Unit Root and cointegration, Error Correction Model, Toda and Yamamoto Procedure,

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1. Introduction

Energy is a key source of economic growth because many production and consumption activities involve energy as a basic input. Energy is one of the most important inputs for economic development. From a physical viewpoint, the use of energy drives economic productivity and industrial growth and is central to the operation of any modern economy. Barney & Franzi (2002) argue that energy is responsible for at least half the industrial growth in a modern economy while representing less than one tenth of the cost of production.

Some analysts argue that growth in energy use directly causes growth in GDP. The energy crises in the 1970's and high-level energy prices slowed down the economic growth. Since the end of 1970s the relationship between energy consumption and economic growth has been studied extensively using modern advances in the time series econometric. Many studies suggest that energy consumption has a high positive correlation with economic growth. Whether economic growth takes precedence over energy consumption or energy consumption boosts the economic growth have been examined in a number of studies yet empirical evidence is mixed and conflicting.

From policy perspective, the causality in either direction between energy consumption and economic growth may have a significant impact upon energy

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Acknowledgement: Author is thankful to Ms Shamsheer Iqbal for her help and Dr.Eatzaz Ahamad for some useful comments.

conservation policies. The energy conservation measures may or may not be taken depends on the direction of causality (Rufael, 2006). For example the unidirectional causality from economic growth to energy consumption imply a less energy-dependent economy, therefore, energy conservation policy has no affect on economic growth. But causality from energy consumption to economic growth implies that in energy-dependent economy energy conservation policies may harm economic growth. No- causality in either direction means energy conservation policy does not affect economic growth. Finally bi-directional causality indicates both high level of economic activity and energy consumption mutually influence each other. Energy consumption and economic growth are highly dependent and energy conservation measures may negatively affect economic growth.

The objective of this paper is to explore the causal relationship between Gross Domestic Product (GDP) and energy consumption for the five South Asian countries; Pakistan, India, Sri Lanka, Bangladesh and Nepal by using the Error Correction Model of Engle and Granger(1987) and Toda and Yamamoto approach (1995).

To investigate the difference in the behavior of the energy-economic growth relationship across energy types, we disaggregate energy consumption into gas, petroleum, electricity, coal consumption and test for their causal relationship with GDP. We also discuss the possible impact of energy conservation policies in the selected countries

There are very few studies on energy-economic growth relationship for this region as a whole. We have applied Toda and Yamamoto procedure, which avoids bias associated both with unit root testing and cointegration. Most of the previous time series studies are either based on simple Granger causality biviariate analysis or few of them use Error Correction Mechanism. Bangladesh a growing economy in the region has been included in this study and most probably it is the first ever study in which Nepal is also included.

In section two we briefly review previous empirical work on the subject. Section three is about the methodology. In section four we analyze the results. Finally study is concluded and policy implications are discussed in section five.

2. Literature review

Increase in the aggregate level of the demand for energy in the last couple of decades makes it important to study the relationship between energy and economic growth for making decision whether energy conservation policies could be adopted without having compromise on economic growth. The pioneering study on the issue was by Kraft and Kraft (1978).They utilized Sims (1972) approach to find the causal relationship between gross energy inputs and Gross National Product(GNP) for USA using the annual data over the period of 1947–1974. They found an evidence of unidirectional causality running from GNP to energy consumption so economic activity may influence energy consumption and energy consumption has no causal influence on economic growth. So energy conservation policy has no impact on economic growth.

Akarca and Long (1980) used same data over the period of 19471972 and failed to support the Kraft (1978) results and found no causality between energy consumption and economic growth. So there is no consensus in the causal direction even for the same country with data slightly different, i-e one is using 1947–1972 and another is using 1947-1974. Just use of two more observations has changed the results.
Yu and Jin (1992) used monthly data over the period 1974:1–1990:4 for USA and examined the causal relationship between energy consumption, GNP and employment. They do not find any causality between energy consumption and economic growth .They support Akarca and Long (1980) results. Earlier studies of energy-growth relationships focused on U.S economy; later on these were extended to other countries.

Soytas and Sari (2002)) considered top 10 emerging markets. For G-7 countries cointegrating relationship exist. For Turkey, France, Germany and Japan results indicate that in the long run unidirectional causality is from energy consumption to GDP. For Italy and Korea long run unidirectional causality from GDP to energy consumption and for Argentina and Turkey short run bi-directional causality is detected.

Masih (1999) investigate the causal and cointgrated relationship between the total energy consumption and real income of six Asian countries; India, Pakistan, Malaysia, Singapore, Philippines and Indonesia. For India, Pakistan and Indonesia there is cointegrating relationship between the energy consumption and income. For India flow of causality is from energy consumption to income so shortage of energy affects the economic growth and for Pakistan there is mutual causality.

Asafu-Adjaye (2000) found the unidirectional Granger causality running from energy consumption to GDP for India and in the long run there is unidirectional Granger causality running from energy and price to income.

Aqeel and Butt (2001) for Pakistan considered total energy consumption as well as different component of energy consumption that are oil, gas, coal, electricity consumption and have checked their causality with economic growth. They found no cointegrating relationship between the variables and there is unidirectional causality running from electricity to economic growth and also from economic growth to the total energy consumption and economic growth to oil consumption.

Ghosh (2002) found no long run equilibrium relationship between electricity consumption and economic growth for India but found the unidirectional Granger causality running from economic growth to electricity consumption.

Morimoto and Hope (2004) examined the impact of electricity supply on economic growth in Sri Lanka and found unidirectional causality running from electricity supply to economic growth; therefore, power shortage in Sri Lanka has serious impact on country's economic growth.

Paul and Bhattacharya (2004) investigate the causality between energy consumption and Economic growth in India and the result of Engle- Granger cointegration combined with standard Granger causality test shows the bi-directional causality between energy consumption and Economic growth.

So there are mixed results from one study to another not only for developed countries of the world but also for the South Asian region. Therefore, we have explored Energy and Economic growth relationship for South Asia by applying some advanced time series techniques.

3. Methodology

We have used Engle-Granger(1987) procedure for testing the null of no cointegration. The null of no cointegration implies that estimated residuals are I(1), whereas the alternative of cointegration means that the estimated residuals are I(0). We have used ADF test statistics for unit root testing of these residuals.Second method which we have used is Toda and Yamamoto which is described as follow.

In Granger sense the causality test is conventionally conducted by estimating Autoregressive or Vector Autoregressive (VAR) models. Granger non-causality test used Wald F- test in an unrestricted VAR model to test the joint significance of some parameters. Sims et al.(1990) and Toda and Phillips(1993) studies have shown that when time series data are integrated or cointegrated then F-test for Granger non-causality is not valid as the test does not have a standard distribution .(also see Caporale and Pittis 1999,Giles and Mizra1998).Toda and Yamamoto (1995) and Dolado and Lütkepohl (1996) proposed the modified Wald test (MWALD) for testing restriction on the parameters of VAR model. In order to apply Toda and Yamamoto (T&Y) approach information about true lag length and maximum order of integration $d_{\max}$ is required but it does not require pre-testing for the cointegration properties of system (Shan and Tian, 1998; Zapata and Rambaldi, 1997).

T&Y has shown that pretesting for cointegration rank in Johansen type ECM are sensitive to the values of the nuisance parameters , thus causality inference may be severely biased.Toda and Yamamoto procedure is to fit the Autogressive or VAR in the level of the variable rather than first difference as in Granger non-causality test.
The basic idea of TY approach is to artificially augment the correct order k , of the VAR model by maximal order of integration, say $d_{\max}$. Once this is done a VAR model with $(d_{\max}+k)$ order is estimated and then coefficient of last lagged vector $d_{\max}$ are ignored means exclude extra added lags and apply the standard Wald test to test the restriction on the parameters.

To represent the GDP-energy consumption model in the VAR system T&Y version of Granger non-causality test has the following form.

$$Y_t = \alpha_0 + \sum_{i=1}^{n}\alpha_{1i}X_{t-i} + \sum_{i=n+1}^{d_{\max}}\alpha_{2i}X_{t-i} + \sum_{j=1}^{m}\phi_{1j}Y_{t-j} + \sum_{j=m+1}^{d_{\max}}\phi_{2j}Y_{t-j} + \varepsilon_{t1} \qquad (3.1)$$

$$X_t = \delta_0 + \sum_{i=1}^{k}\delta_{1i}X_{t-i} + \sum_{i=k+1}^{d_{\max}}\delta_{2i}X_{t-i} + \sum_{j=1}^{l}\varphi_{1j}Y_{t-j} + \sum_{j=l+1}^{d_{\max}}\varphi_{2j}Y_{t-j} + \varepsilon_{t2} \qquad (3.2)$$

Where X_t can be log of total energy consumption, electricity consumption, gas consumption, coal consumption and petroleum consumption and Y_t is the log of real GDP. The initial lag length n, m, k, and l are chosen using AIC criterion. Where ε_{t1} and ε_{t2} are the error terms.

From Eq (3.1), Granger causality from X_t (energy) to Y_t (GDP) implies $\alpha_{1i} \neq 0 \ \forall_i$;

Similarly in Eq (3.2) Y_t (GDP) Granger cause X_t (energy), if $\varphi_{1j} \neq 0 \ \forall_i$.

T&Y proves that Wald statistic used converges in distribution to a

χ^2, no matter whether the process is stationary or non-stationary and whether it is cointegrated or not .

4. Data Description and Empirical Results

For India, Pakistan Bangladesh and Nepal, annual data of nominal Energy consumption with its various types (Petroleum, Gas, Coal, Electricity and Total Energy Consumption) are taken from International Energy Agency (IEA), 2005 from energy balance of non-OECD countries (2003 edition). All variables of energy consumption are measured in millions of tones of oil equivalent except for coal consumption of Pakistan which is in 000 metric tonne. GDP series for all the five countries are obtained from CD of International Financial Statistics and converted into real GDP by using GDP deflator for each country. For Pakistan Real GDP is in Billions of Pakistani Rupee, measured at 2000 constant price, Indian Real GDP is in Billions of Indian Rupee with 1995 price, Bangladesh Real GDP is in Billions of Takka measured at 2000 constant price, Sri Lanka GDP is in Millions of Sri Lankan Rupee measured at 2000 constant price and Nepal Real GDP is in million of Nepali Rupee with 2000 constant price level.

Since data range depend on the availability of data, we take yearly data of time series variables covering the period of 1971 – 2003 except for Sri Lanka (1980-2003) where Sri Lanka data were taken from Energy International Administration (eia) website. Electricity consumption is measured in Billion Kilowatt-hours, petroleum consumption is measured in Thousand Barrels per Day and total energy consumption is measured in Quadrillion (10^{15}) Btu. gas consumption series is not available for Nepal so this variable has been ignored for this country.

The variable notations and definitions are as follows.

PC : Petroleum Consumption
EC : Electricity Consumption
GC : Gas Consumption
CC : Coal Consumption
TC : Total energy Consumption
LGDP : Real GDP

All variables are transformed into natural logarithms.

In order to determine the order of integration of the variables involved Augmented Dickey–Fuller (ADF) (1979) is used. The null hypothesis that variable under consideration has unit root against the alternative hypothesis that it is stationary. Result of ADF test at level and first differenced are reported in Table A-1 (Appendix).

Results of ADF test indicate that for Pakistan, India , Sri Lanka and Nepal, all series of energy consumption and real GDP are stationary at first difference i.e.*I(1)*. But for Bangladesh coal and total energy consumption are *I(0),* therefore, in performing the cointegrating analysis we do not consider these two variables in analysis.

We have tested the coitegrating relationship for all the countries by using Engle-Granger procedure. There are mixed results on cointegration. There is cointegrating relationship only for some of the variable in case of Pakistani and Sri Lanka; therefore, results of causality through error correction mechansim are reported in Table 1. In the next step we have applied T&Y procedure, which avoids bias associated with unit root testing and cointegration. . T&Y approach use level of the variables even if the variables are individually non-stationary and not cointergrated. AIC and SBC is used for selecting the initial lag length. In T&Y model initial lag length is augmented with extra lag (s), which depends upon order of integration.

These results are summarized in Table 2.Table A-3,A-4,A-5,A-6 and A-7 show T&Y results for Pakistan, India, Sri Lanka ,Bangladesh and Nepal respectively(Appendix). Summary of the Results:

Table 1

Causality results based on ECM

Countries	**Direction of causality Null Hypothesis**	**Short term**	**Long term**
Pakistan	TC does not Granger cause LGDP	Not Reject	Not Reject
	LGDP does not Granger cause TC	Not Reject	Reject
Srilanka	EC does not Granger cause LGDP	Not Reject	Not Reject
	LGDP does not Granger cause EC	Not Reject	Reject

Note. Using 5% level of significance

Table 2
Causality results based on Toda and Yamamoto (1995) test

Direction of causality Null Hypothesis	**Pakistan**	**India**	**Sri Lanka**	**Bangladesh**
PC does not Granger cause LGDP	Not Reject	Not Reject	Not Reject	Not Reject
LGDP does not Granger cause PC	Not Reject	Not Reject	Not Reject	Not Reject
EC does not Granger cause LGDP	Not Reject	Not Reject	Not Reject	Not Reject
LGDP does not Granger cause EC	Reject	Not Reject	Reject	Reject
GC does not Granger cause LGDP	Not Reject	Not Reject	N.A	Reject
LGDP does not Granger cause GC	Not Reject	Not Reject	N.A	Not Reject
CC does not Granger cause LGDP	Reject	Not Reject	N.A	Not Reject
LGDP does not Granger cause CC	Not Reject	Not Reject	N.A	Not Reject
TC does not Granger cause LGDP	Not Reject	Not Reject	Not Reject	Not Reject
LGDP does not Granger cause CC	Reject	Not Reject	Reject	Not Reject

Note N.A means series are not available. Use 5% level of significance.

5. Summary and Conclusions

Knowledge of the direction of causality between GDP and energy consumption is important for making a decision whether energy conservation policies affect economic growth or not.

For Pakistan we find that total energy consumption and GDP are cointegrated and in the long run there is unidirectional Granger causality running from GDP to total energy consumption. This means that continuous growth in GDP simultaneously generates a continuous increase in total energy consumption and energy conservation may be feasible without compromising on economic growth. But there is no evidence of Granger causality between GDP and petroleum consumption, GDP and gas consumption which implies that energy conservation policies (gas and petroleum sector) may be pursued without adversely affecting income. Moreover there is unidirectional causality running from coal to GDP this means reducing coal consumption may lead to fall in GDP. The evidence of unidirectional causality from GDP to electricity consumption and from GDP to total energy consumption is an indication that rapid growth in GDP is responsible for high level consumption in electricity and total energy consumption. This is exactly what we have been observing in practice in Pakistan that it has become an elecetricity deficient country from electricity surplus with an increase in GDP over last five six years. Nevertheless, energy conservation policies may be implemented with little adverse or no affect on Economic growth.

For India, there is no evidence of causal relationship between GDP and all types of energy consumption, which means that neither GDP nor all types of energy consumption Granger Cause each other. The neutrality hypothesis implies that reducing energy consumption may not affect GDP and it appears that energy conservation policies may not have significant impact on GDP growth.

For Sri Lanka, our main findings are that electricity consumption and GDP are cointegrated and in the long run there is unidirectional causality running from GDP to electricity consumption. Then this denotes a less energy dependent economy, one where the implementation of energy conservation policies would have little, if any, adverse effect on income. There is evidence of unidirectional causality running from GDP to electricity consumption and from GDP to total energy consumption. This means that increase in economic growth require enormous consumption in electricity and total energy. As economic growth causes expansion in industrial and commercial activities and electricity is used as a basic input, therefore, energy conservation policies do not harm the economic growth.

For Bangladesh coal, petroleum, total energy consumption and GDP are independent which favors neutrality hypothesis, therefore, energy conservation policies may not effect economic growth. But there is unidirectional Granger causality running from GDP to electricity consumption this means that if economic growth increases, and then electricity consumption also increases. So electricity conservation policies would not adversely affect economic growth of Bangladesh. Evidence of unidirectional causality from gas to GDP implies that an increase in gas consumption can be viewed as a leading indicator of economic growth, this which means that the supply of gas is vitally important to meet the growing electricity consumption to sustain the economic growth.Shortage of gas may cause poor economic performance and that leads to fall in GDP. Such causal relationship between GDP and gas consumption suggests that energy conservation policies are likely to affect the GDP growth. So energy conservation (gas sector) policies should be such that they curtail the consumption without affecting economic growth.

For Nepal there is no cointegrated relation between GDP and various energy consumption variables. But there is unidirectional causality running from petroleum to GDP this means reducing petroleum consumption may harm economic growht. But no evidence of Granger causality between GDP and electricity, coal and total energy consumption indicate that energy conservation policies may be pursued without adversely affecting income.

In general, our results indicate that increase in energy demand is mainly driven by high economic activity in the region. This implies that sustainable growth in GDP can be achieved by judicious energy conservation policies. With all this we would like to say that our results may be sensitive to the choice of sample period, selection of variables and methodology we adopted. This also indicates the sensitivity of Granger causality and that's why results based on Granger causality should be interpreted with care. Finally we suggest that result may suffer from the omission of the other relevant variables. Hence, in future, study can be improved by including more relevant variables such as Energy price, Employment and Capital etc. Panel data analysis of these four countries' data might also lead to interesting findings for the whole region.

References

Akarca, A.T. and Long, T.V.(1980). "On the relationship between energy and GNP: a re-examination". *J. Energy Dev.* 5: 326–331.

Aqeel, A., Butt, M.S. (2001). "The Relationship between Energy Consumption and Economic Growth in Pakistan". *Asia-Pacific Development Journal* 8(2): 101-109.

Asafu-Adjaye, J. (2000). "The Relationship between Energy Consumption, Energy Prices and Economic Growth:Time Series Evidence from Asian Developing Countries". *Energy Economics* 22: 615-625.

Barney .F, Franzi .P.(2002). "The future of energy From Future Dilemmas: Options to 2050 for Australia's population, technology, resources and environment". *CSIRO Sustainable Ecosystems.*pp157 – 189.

Dickey, D. A. & Fuller, W. A. (1979). "Estimators for autoregressive time series with a unit root", *Journal of the American Statistical Association* 74: 427-431.

Engle, R.F., and C.W.J. Granger (1987). "Co-Integration and Error Correction: Representation, Estimation, and Testing"; *Econometrica* 55: 251-276.

Ghosh, S. (2002). "Electricity Consumption and Economic Growth in India". *Energy Policy* 30: 125-129.

International Energy Agency (IEA) (2003) *Energy Balances of NON-OECD Countries.* Paris, France.

Kraft, J., Kraft, A. (1978) Note and Comments : " On the Relationship between Energy and GNP". *The Journal of Energy and Development* 3: 401-403.

Masih, A.M.M., Masih, R. (1999) "Energy Consumption, Real Income and Temporal Causality: Results from a Multi-Country Study based on Cointegration and Error-Correction Modelling Techniques". *Energy Economics* 18: 165-183.

Morimoto, K., Hope, C., (2004). "Impact of electricity supply on economic growth in Sri Lanka". *Energy Economics* 26, 77–85.

Paul, S., Bhattacharya, R.N., (2004). "Causality between energy consumption and economic growth in India: a note on conflicting results" *Energy Economics* 26: 977–983.

Rufael, Y. Wolde, (2006). "Electricity consumption and economic growth: A time series experience for 17 African countries". *Energy Policy 34:* 1106 – 1114.

Sargan, J.D.(1964). "Wages and prices in the United Kingdom: a study in econometric methodology". In: Hart, P.E., Mills G., Whitaker, J.K. (Eds.), *Econometric Analysis for National Economic Planning Butterworths*, London.

Shan, J., Tian, G.G., (1998). "Causality between exports and economic growth: the empirical evidence from Shanghai". *Aust. Econ. Pap.* 37: 196–202

Sims,C.A., J.H.Stock and M.W.Watson (1990), "Inference in Linear Time Series Models with Some Unit Roots", *Econometrica* 58: 113-144.

Soytas, U., Sari, R. (2002). "Energy Consumption and GDP: Causality Relationship in G-7 Countries and Emerging Markets". *Energy Economics* 25: 1-118.

Toda, H.Y., Yamamoto, T., (1995). "Statistical inference in vector autoregressions with possibly integrated process". *Journal of Econometrics* 66:225–250.
Yu, E.S.H., Jin, J.C. (1992) "Cointegration Tests of Energy Consumption, Income, and Employment". *Resources and Energy* 14: 259-266.
Zapata, H.O., Rambaldi, A.N., (1997). "Monte Carlo evidence on cointegration and causation". *Oxford Bulletin of Economics and Statistics* 59: 285–298.

Appendix

Table A-1

Unit root tests Augmented Dickey and Fuller 1979 test regression.

Variables	**Pakistan**		**India**		**Sri Lanka**		**Bangladesh**	
	Level	1st Dif	Level	1st Dif	Level	1st Diff	Level	1st Dif
PC	- 1.42 (0)	- 4.58 (1)	- 0.32 (0)	- 4.33 (1)	-1.54 (0)[b]	- 4.49 (1)	- 2.83 (0)[b]	- 5.23 (1)*
GC	- 1.64(0)	- 4.78(2)	- 1.89(0)	- 4.80(1)	N.A	N.A	- 1.49(1)[b]	- 7.13(1) *
EC	- 1.47(0)	- 4.70(1)	1.35(0)	- 3.92(1)	- 3.52(0)[b]	- 5.84(1)	- 3..35(0)[b]	- 5.74(2) *
CC	- 0.14(0)	- 7.16(1)	1.76(0)	- 6.20(1)	N.A	N.A	- 3.19(0)*	__
TC	- 1.33(0)	- 5.03(1)	0.70(0)	- 6.46(1)	- 2.05(0)[b]	- 5.79(1)	- 3.71(0)[b]*	__
LGDP	- 1.77(0)	- 4.91(1)	2.33(0)[b]	- 6.66(1)	- 2.17(0)[b]	- 4.50(1)	- 3.29(0)[b]	- 9.23(1) *

Variables	**Nepal**	
	Level	1st Difference
PC	**- 2.15(0)**	**- 5.98(1)**
EC	- 1.43(2)	- 3.46(2)
CC	- 4.15(0)	-----
TC	- 3.69(1)	-----
LGDP	- 2.79(0)	- 6.37(1)

Note. The no of lags that whiten the error term in Lagrange Multiplier test are in parentheses.
a. MacKinnon critical values for rejection of hypothesis of a unit root at 5% level of significance.
b. Trend is significance use MacKinnon critical values including trend and intercept at 5% level of significance.
* Significance at 5% level of significance.
** Trend is only included when it turned out to be significant.

Table A-2.
Unit root tests of Residuals.

Variables	Pakistan	India	Sri Lanka	Bangladesh	Nepal
(LGDP, PC)	- 2.21(0)	- 1.1(0)	- 2.32(0)	- 2.66(0)	- 3.04(0)
(LGDP, GC)	- 2.57(0)	- 0.05(0)	-----	- 2.17(0)	-------
(LGDP, EC)	- 2.47(0)	- 0.02(0)	- 4.54(0)**	- 2.98(0)	- 1.71(0)
(LGDP, CC)	- 3.24(0)	- 0.02(0)	-----	-----	--------
(LGDP, TC)	- 3.92(0)**	- 0.89(0)	- 2.48(0)	------	--------

Note. The no of lags that whiten the error term in Lagrange Multiplier test are in parentheses. a . MacKinnon critical values for rejection of hypothesis of a unit root at 5% level of Significance. ** Significance at 5% level.

Table A-3
Test of bivariate causality, T&Y approach Pakistan (1971 – 2003)

Direction of causality	m	l	AIC	SBC	MWALD statistics	Conclusion
PC ⇒LGDP	2	2	- 5.087	- 4.586	0.046(0.831)	PC ≠> LGDP
LGDP⇒PC	2	2	- 3.468	- 3.237	1.025(0.321)	LGDP ≠> PC
EC ⇒LGDP	2	2	- 5.175	- 4.94	0.926(0.345)	EC ≠> LGDP
LGD ⇒EC	2	3	- 3.440	- 3.159	3.905(0.034)*	LGDP ⇒ EC
GC ⇒ LGDP	2	2	- 5.105	- 4.873	0.021(0.964)	GC ≠>LGDP
LGDP⇒ GC	2	2	- 3.181	- 2.950	1.100(0.304)	LGDP ≠> GC
CC ⇒ LGDP	2	2/3 *	- 5.300	- 5.033	4.101(0.029)$_a$ *	CC⇒ LGDP
					5.158(0.032)$_b$ *	CC ⇒ LGDP
LGDP ⇒ CC	2	2	- 1.487	- 1.256	3.113(0.090)	LGDP ≠> CC
TC ⇒LGDP	2	2	- 5.121	- 4.889	1.013(0.324)	TC ≠> LGDP
LGDP ⇒ TC	2	2	- 4.125	- 3.893	5.907(0.022)*	LGDP ⇒ TC

a. Model with m = 3 and l = 2 give minimum SBC. b. Model with m= 3 and l = 3 gives minimum AIC. We consider both but conclusion is same

Table A-4 Test of bivariate causality, T&Y approach India (1971 – 2003)

Direction of causality	**m**	**l**	**AIC**	**SBC**	**MWALD statistics**	**Conclusion**
PC ⇒ LGDP	2	2	- 4.194	- 3.963	0.164(0.689)	PC ≠> LGDP
LGDP ⇒PC	2	2	- 3.967	- 3.736	1.054(0.314)	LGDP ≠> PC
EC⇒ LGDP	2	2	- 4.207	- 3.976	0.405(0.530)	EC ≠> LGDP
LGDP⇒ EC	2	3	- 4.078	- 3.847	2.722(0.860)	LGDP ≠> EC
GC⇒LGDP	2	2	- 4.207	- 3.975	1.111(0.305)	GC ≠> LGDP
LGDP ⇒GC	2	2 /3*	- 0.911	- 0.667	1.852(0.179)[a]	LGDP ≠> GC
					3.208(0.085)	LGDP ≠> GC
CC⇒ LGDP	2	2	- 4.178	- 3.947	0.311(0.582)	CC ≠> LGDP
LGDP⇒ CC	2	2	- 2.379	- 2.149	2.205(0.150)	LGDP ≠> CC
TC⇒LGDP	2	2	- 4.123	- 3.897	0.365(0.550)	TC ≠> LGDP
LGDP⇒TC	2	2	- 4.246	- 4.010	3.107(0.091)	LGDP ≠> TC

a. Model with m = 2 and l = 2 give minimum SBC. b. Model with m= 3 and l = 3 gives minimum AIC. We consider both but conclusion is same

Table A-5

Test of bivariate causality ,TY approach Sri Lanka(1980 – 2003)

Direction of causality	m[a]	l[b]	AIC	SBC	MWALD Statistics	Conclusion
PC⇒LGDP	2	2	- 4.538	- 4.290	3.63E-07(0.999)	PC ≠>LGDP
LGDP⇒PC	2	2	- 2.052	- 1.804	0.0147(0.905)	LGDP ≠>PC
EC⇒LGDP	2	2	- 4.599	- 4.352	1.049(0.320)	EC ≠> LGDP
LGDP⇒EC	2	2	- 2.948	- 2.700	5.884(0.027)*	LGDP⇒EC
TC ⇒LGDP	2	2	- 4.555	- 4.307	0.127(0.726)	TC ≠> LGDP
LGDP⇒TC	2	2	- 2.633	- 2.384	4.178(0.057)*	LGDP ⇒ TC

Table A-6
Test of bivariate causality, TY approach Bangladesh (1971 – 2003)

Direction of causality	**m**	**l**	**AIC**	**SBC**	**MWALD statistics**	**Conclusion**
PC LGDP	3	2	- 5.100	- 4.815	1.148(0.296)	PC ≠> LGDP
LGDP PC	2	2	- 1.998	- 1.762	1.825(0.189)	LGDP ≠> PC
EC LGDP	3	2/3	- 5.242	- 4.914	0.624(0.431)$_a$	EC ≠> LGDP
					0.389(0.682)$_b$	EC ≠> LGDP
LGDP EC	3	2	- 2.579	- 2.294	4.476(0.046)*	LGDP ⇒ EC
GC LGDP	2	2/3	- 5.459	- 5.181	16.72(0.0004)$_c$*	GC ⇒ LGDP
					10.35(0.0007)$_d$*	GC ⇒ LGDP
LGDP GC	3	2	- 1.900	- 1.615	0.095(0.761)	LGDP ≠> GC
CC LGDP	3	1	- 5.121	- 4.883	0.045(0.835)	CC ≠> LGDP
LGDP CC	2	3	2.294	2.58	0.739(0.489)	LGDP ≠> CC
TC LGDP	3	1	- 5.137	- 4.89	0.422(0.522)	TC ≠> LGDP
LGDP TC	1	2	- 2.682	- 2.494	0.125(0.727)	LGDP ≠> TC

Note m is final selected lag length of dependent variable . l is final selected lag length of independent variable * Significance at 5% level P – Values are in parenthesis ⇒ Denotes the rejection of null hypothesis of non-causality ≠> Denotes the not rejection of null hypothesis of non-causality a. Model with m = 3 and l = 2 give minimum SBC. b. Model with m= 3 and l = 3 gives minimum AIC. We consider both but conclusion is same. c. Model with m = 2 and l = 2 give minimum SBC. d. Model with m= 2 and l = 3 gives minimum AIC. We consider both but conclusion is same.

Table A-7

Test of bivariate causality, TY approach Nepal (1971 – 2003)

Direction of causality	**m**	**l**	**AIC**	**SBC**	**MWALD statistics**	**Conclusion**
PC ⇒LGDP	3	3	- 4.580	- 4.300	3.504(0.0469)*	PC ⇒ LGDP
LGDP⇒ PC	2	2	- 1.814	- 1.583	1.960(0.173)	LGDP ≠> PC
EC ⇒ LGDP	3	2	- 4.548	- 4.267	1.129(0.297)	EC ≠> LGDP
LGDP⇒ EC	3	2	- 2.607	- 2.327	0.780(0.386)	LGDP ≠> EC
CC⇒ LGDP	3	1	- 4.353	- 4.120	0.600(0.446)	CC ≠> LGDP
LGDP⇒ CC	2	3	2.386	2.666	1.980(0.160)	LGDP ≠> CC
TC ⇒ LGDP	1	3	- 4.383	- 4.15	1.377(0.252)	GC ≠> LGDP
LGDP⇒ TC	1	2 /3	- 0.989	- 0.756	0.000008(0.998)[a]	LGDP ≠> GC
					2.965(0.0699)	LGDP ≠> GC

a. Model with m = 1 and l = 2 give minimum SBC. b. Model with m= 1 and l = 3 gives minimum AIC. We consider both but conclusion is same