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Dynamic Modelling of Energy and Growth in South Asia

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1. INTRODUCTION

Energy plays an important role on the demand and the supply sides of the economy. On the demand side, energy is one of the products a consumer decides to buy to maximise his utility. On the supply side, energy is the key factor of production in addition to labour, capital and other raw materials. Energy is considered to be the key element in the socio-economic development of a country. It also helps to improve the living standards of the society through the increase in economic growth. This implies that there is a causal link running from energy consumption to economic growth.

If causality runs from energy consumption to GDP then it implies that an economy is energy dependent and hence energy is a stimulus to economic growth [Jumbe (2004)]. Shortage of energy may negatively affect economic growth and may cause poor economic performance leading to a reduction of income and employment. On the other hand, if causality runs from GDP to energy consumption, this implies that economy is not energy dependent, and hence energy conservation policies may be implemented without adverse effects on economic growth and employment [Masih and Masih (1997)]. If there is no causality between energy consumption and GDP, it implies that energy conservation policies may be pursued without affecting the economy [Jumbe (2004)]. Based on these arguments, it is necessary to analyse the link between energy consumption and economic growth because it is often argued that the increased availability of energy services act as key stimulus of the process of economic development.

The relationship between energy consumption and economic growth has been studied extensively, but the issue associated to the direction of causality between energy consumption and economic growth still remained unsettled. Kraft and Kraft (1978) has found unidirectional causality running from GNP to energy consumption for United States for the period 1947–1974. Their results indicates that the low level of energy dependence of US economy on energy enable US to pursue energy

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conservation policies which have no adverse effects on income [Jumbe (2004)]. Akarca and Long (1980) has pointed out that Kraft and Kraft results were spurious by changing the time period by 2 years. The *neutrality hypothesis*[1] was found by Yu and Hwang (1984), Yu and Choi (1985), Yu and Jin (1992) and Cheng (1995). In the context of developing countries Masih and Masih (1996) found the evidence of Granger causality running from income to energy for Indonesia, but Fatai, *et al.* (2004) found unidirectional causality running from energy consumption to income. Asafu-Adjaye (2000) examined the causal relationship between energy consumption, energy prices and economic growth for India, Indonesia, Philippines and Thailand over the period 1971-95 for India and Indonesia and 1973-1995 for Thailand and Philippines. They find unidirectional causality running from energy to income for India and Indonesia and bidirectional causality running from energy to income for Thailand and Philippines. They further find the evidence of unidirectional causality running from energy and prices to income for India and Indonesia and for Thailand and Philippines energy, income and prices are mutually causal. Aqeel and Butt (2001) have investigated the causal relationship between energy consumption and economic growth and energy consumption and employment for Pakistan over the period 1955-56–1995-96. They implemented Hsiao's version of the causality test to determine the direction of causality. Their results suggest that economic growth causes total energy consumption. The study further suggests that economic growth causes the growth of petroleum production, but no causality observed between growth and gas consumption. The study also explored the causality running from electricity consumption to economic growth without any feedback effects. Considering the causality issue, Siddiqui (2004) have examined the relationship between energy and economic growth for Pakistan over the period 1970–2003 using Autoregressive Distributed Lag (ADL) modelling technique. The results suggest that the impact of all sources of energy were not same on economic growth. The findings of this study suggest that the impacts of electricity and petroleum products were high and significant on economic growth. However, the study explored reverse causality between petroleum products and economic growth. Paul and Bhattacharya (2004) examined causality between energy consumption and economic growth for India over the period 1950-1996 applying both Engle and Granger (1987) and Johansen (1988) cointegration approach. The results supported the evidence of unidirectional causality from energy consumption to economic growth. Results based on Engle-Granger cointegration test exhibited unidirectional causality running from GDP to energy consumption in the long-run and no causality evidence was found in the short-run. They pointed out that when Engle-Granger approach combined with standard Granger causality test, the evidence of bi-directional causality between energy consumption and economic growth was found. The authors concluded that the long-run causal relation running from GDP to energy consumption and the short-run causal relation running from energy consumption to GDP.

From the survey of empirical literature we come to the conclusion that although these studies have made significant contributions regarding the relationship between

[1]If there is no causality between energy consumption and GDP exist, referred as neutrality hypothesis.

energy consumption and economic growth, but not sufficiently shed lights on the dynamic insights of the energy-growth relationship. We feel that the relationship between energy consumption and economic growth may consider together with other economic factors such as labour and capital. The complexity of relationship among these variables requires a re-examination of long-term and short-term linkages between energy consumption and real output in Bangladesh, India, Pakistan and Sri Lanka over the period 1972–2004.

The paper is organised as follows: Section 2 shed lights on the energy market in South Asia. Model and data is discussed in Section 3. Empirical results and their interpretation are given in Section 4, while concluding remarks and policy implications are given in the final section.

2. OVERVIEW OF THE ENERGY SECTOR IN SOUTH ASIA[2]

Economic growth in south Asia resulted in a rapid increase in energy consumption in recent years. The Energy Information Administration [EIA (2004)] estimates of South Asia's primary energy consumption showed an increase of nearly 64 percent between 1992 and 2002.[3] In 2002 South Asia, accounted for approximately 4.1 percent of the world commercial energy consumption, up from 2.8 percent in 1992. However, despite the growth in energy demand, South Asia continue to average among the lowest levels of the per capita energy consumption in the world, but among the highest levels of energy consumption per unit of GDP.

The commercial energy in South Asia in 2002 was 46 percent coal, 34 percent petroleum, 12 percent natural gas, 6 percent hydroelectricity, 1 percent nuclear and 0.3 percent others. There are significant variations in the region. For example, Bangladesh energy mix was dominated by natural gas (66.4 percent in 2002), while India relies heavily on coal (54.5 percent in 2002); Sri Lank is overwhelmingly dependent on petroleum (82 percent). Pakistan has diversified among petroleum (42.7 percent), natural gas (42.2 percent), and hydroelectricity (10 percent).

South Asian nations facing rapidly increasing demand for energy coupled with insufficient energy supply. Most of the South Asian countries are already grappling with energy shortfalls in the form of recurrent, costly, and widespread electricity outages. Because of the economic and political ramifications arising from such shortfalls, improving the supply of energy, particularly the supply of electricity, is an important priority of regional governments. South Asian countries are looking to diversify their traditional energy supplies, attract additional foreign investment for energy infrastructure development, improve energy efficiency, reform and privatise energy sector and promote and develop regional energy trade and investment.

The commercial per capita energy consumption in the region continuous to be quite low, indicating the potential for greater energy consumption. The per capita energy consumption pattern of Bangladesh, India, Pakistan and Sri Lanka is reported in Table 1.

[2]This section is heavily based on the "South Asia Regional Overview" available from www.eia.doe.gov.

[3]EIA energy statistics include only commercial energy and not animal waste, wood, or other biomass which accounts for more than half of the South Asia's total energy consumption.

Table 1

Per capita of Energy Consumption in South Asia (in KGOE)

Year	Bangladesh	India	Pakistan	Sri Lanka	South Asia	World
1990	123.27	425.65	402.17	324.15	394.43	1685.28
1991	118.73	435.24	404.69	324.32	401.73	1676.55
1992	121.9	441.95	419.08	329.74	405.07	1652.61
1993	125.14	445.03	429.97	343.31	408.94	1648.05
1994	127.48	451.1	435.72	325.14	414.1	1635.74
1995	137.37	468.24	443.84	328.08	429.04	1655.52
1996	135.3	475.73	453.15	366.55	436.02	1678.75
1997	138.51	484.62	452.39	375.07	443.17	1671.92
1998	141.66	484.46	450.94	377.12	443.15	1661.31
1999	140.74	499.8	464.72	397.05	456.63	1671.49
2000	145.13	503.96	463.15	417.53	460.46	1686.82
2001	155.39	503.44	461.4	422.7	460.91	1677.28
2002	156.63	508.96	456.96	417.74	464.53	1693.42
2003	160.9	515.47	466.91	448.92	471.3	1730.77
2004	163.7	530.55	489.09	485	485.87	1790.49
Average	139.46	478.28	446.28	378.83	438.36	1681.07

Source: World Development Indicators.

It is clear from Table 1 that India has uses highest per capita commercial energy (479.28 KGOE) and Bangladesh has the lowest (139.46 KGOE). The aggregate consumption and production of energy in South Asia can be seen in Table 2a-b.

Table 2

(a) *Energy Consumption (in Kilo Ton of Oil Equivalent)*

Country/Year	1990	1995	2000	2001	2002	2003	2004	Average*
Bangladesh	12826	15997	18710	20428	20993	21981	22789	17090.87
India	361598	436480	511983	519786	533711	548661	572851	4640002.4
Pakistan	43424	54315	63952	65265	66214	69307	74371	57884.67
Sri Lanka	5516	5950	8083	7918	7940	8643	9439	7002.4
South Asia	432790.2	523875	616046	627058.1	642749.4	662887.8	694312.7	557954.8
World	8609872	9118983	9915471	9977883	10193480	10539100	11026260	9507822

(b) *Energy Production (in Kilo Ton of Oil Equivalent)*

Country/Year	1990	1995	2000	2001	2002	2003	2004	Average*
Bangladesh	10758	12777	15156	16178	16739	17549	18390	13866.6
India	361598	436480	511983	519786	533711	548661	572851	395969.6
Pakistan	34360	41272	47130	49204	50295	55492	58993	44230.6
Sri Lanka	4191	4022	4530	4462	4240	4840	5161	4376.47
South Asia	391514.9	452380	495097.3	507704.8	519685	540765.3	562185.5	468949.8
World	8798347	9283481	10029940	10164181	10268170	10651420	11171230	9657296

(c) *Net Energy Import (% of Total Energy Use)*

Country/Year	1990	1995	2000	2001	2002	2003	2004	Average*
Bangladesh	16.2	20.13	19.0	20.8	20.26	20.16	19.3	18.52
India	7.9	11.94	18.55	17.99	18.22	17.88	18.5	14.16
Pakistan	20.87	24.01	26.3	24.61	24.04	19.93	20.68	23.46
Sri Lanka	24.02	32.4	43.96	43.65	46.6	44	45.32	36.30
South Asia	9.54	13.65	19.63	19.03	19.15	18.42	19.03	15.48

(d) GDP per Unit of Energy Use (PPP $ per KOE)

Country/Year	1990	1995	2000	2001	2002	2003	2004	Average*
Bangladesh	9.71	9.65	10.63	10.25	10.42	10.47	10.73	10.23
India	3.89	4.15	4.69	4.86	4.91	5.18	5.37	4.43
Pakistan	4.06	4.07	4.06	4.06	4.13	4.14	4.14	4.08
Sri Lanka	7.27	8.76	8.25	8.29	8.59	8.37	8.08	8.14
South Asia	4.16	4.36	4.85	4.99	5.05	5.27	5.44	4.62
World	3.88	4.14	4.58	4.68	4.72	4.75	4.77	4.32

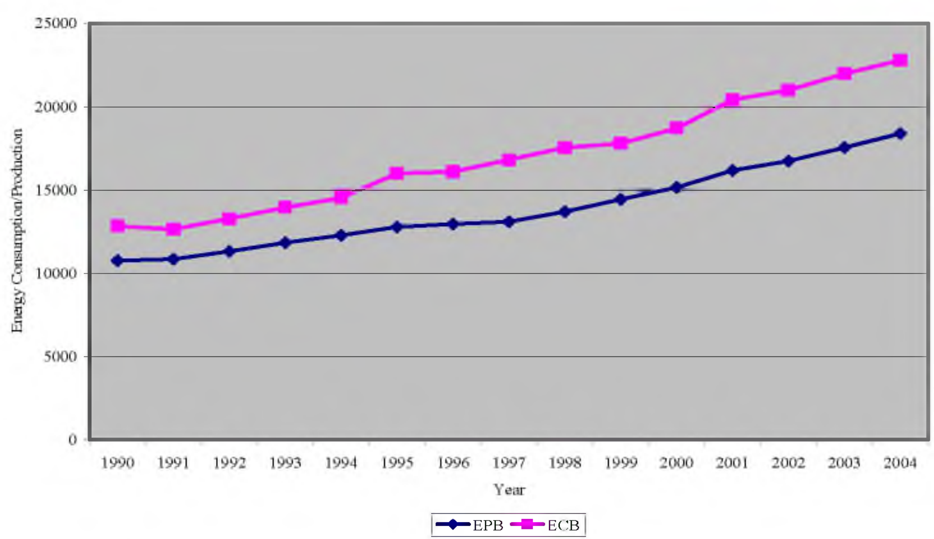
Source: World Development Indicators.

* Average taken from 1990-2003 using World Bank Data.

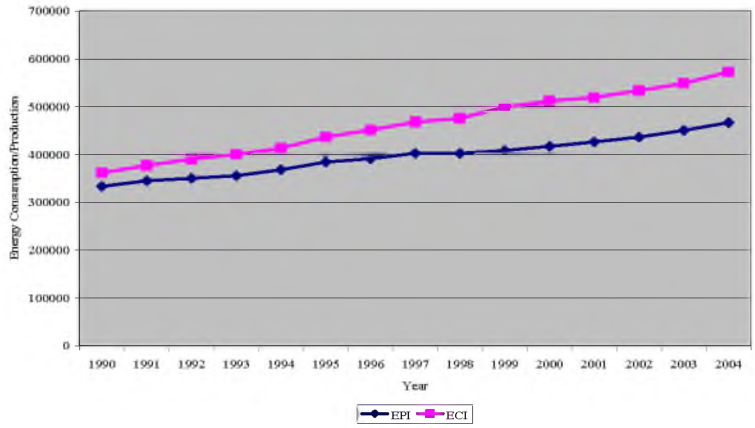
Table 2a-b depicts the trends of energy consumption and the energy production within the region. India is the highest energy user from 1990 to 2004 (464002.4 KTOE on average), and Sri Lanka is the lowest (7004.47 KTOE on average) during the same period, while in terms of production, again India stood the highest producer (395969.6 KTOE), and Sri Lanka has the lowest (4376.47 KTOE). This shows that in South Asia there is wide gap between energy production and energy demand. This can be clearly depicted by Figure(s) 1a-1d.

Fig. 1. Energy Consumption and Energy Production in South Asia (1990-04)

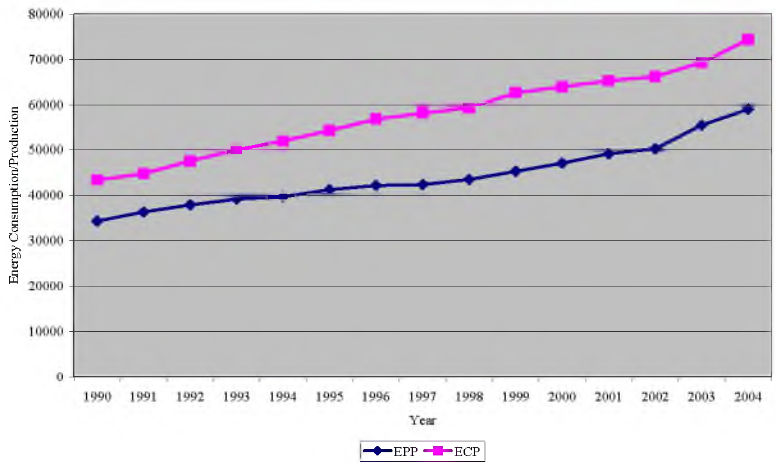
(a) Bangladesh



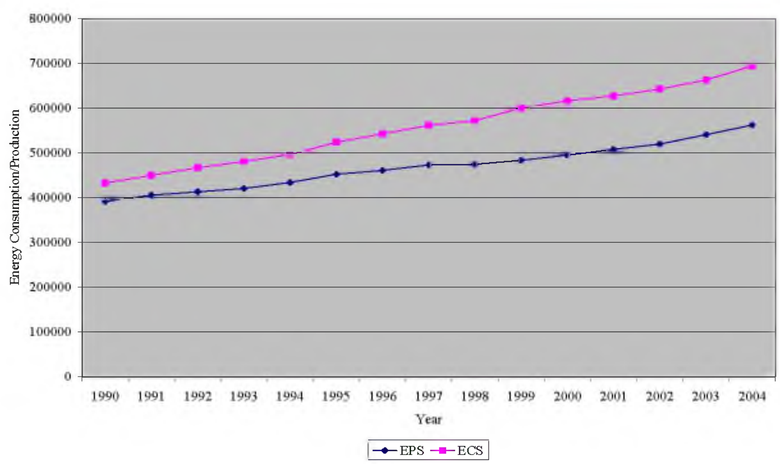
(b) India



(c) Pakistan

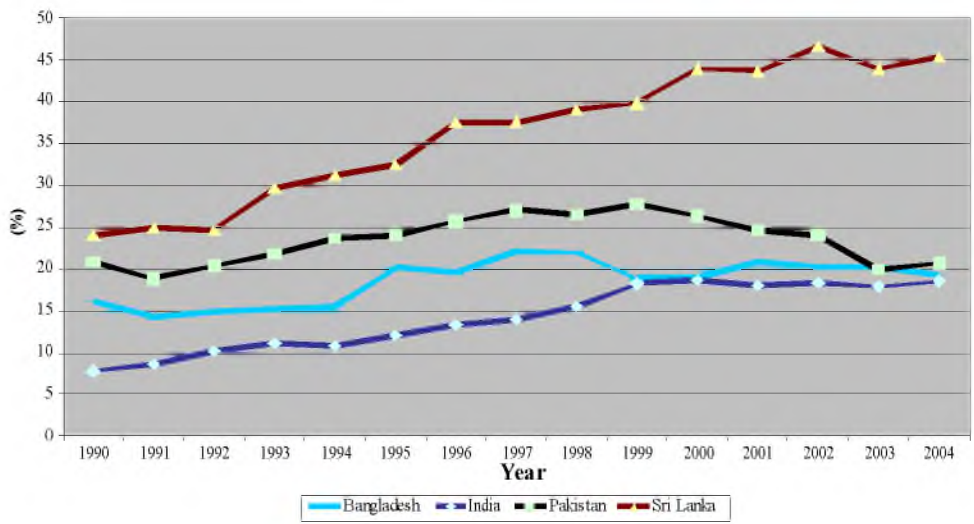


(d) Sri Lanka



The persistent shortage of energy has been the major factor in keeping low economic growth in South Asia [Wickramasinge (2001)]. Poor quality of energy infrastructure has also been one of the major distortions to economic development in the region [*Ibid* (2001)]. South Asia is the net importer of energy. South Asia contains 5.7 billions of oil reserves which is equal to 0.5 percent of the world reserves. The region consumed around 2.72 million barrels of oil per day and produced 0.7 million barrels in 2002, making South Asia net oil importer of around 2.0 million barrels per day. In 2003 production of around 819,000 million barrels of oil per day comes from India, while the remaining around 62,000 barrels of oil per day comes from Pakistan. It is expected that South Asian imports of oil becomes more than double by the end of 2020 and Middle East is expected to remains the primary source of oil imports. The bulk of oil is demanded to meet the growing consumption of transportation, industry, electricity generation and household sectors. From 1990 to 2000, South Asia consumption of oil grew up about 75 percent. India's oil consumption is expected to grow 33 percent by 2010, and reaching to 2.8 million barrels of oil per day from 2.2 million barrels per day in 2002. Oil is the main source of energy in Sri Lanka and its oil consumption is doubled from 1991 to 2000. In 2002 the oil consumption in Sri Lanka was 75,000 million barrels per day. Sri Lanka imported all its crude oil and uses it largely for electricity generation and transportation. This country has refining capacity is around 50,000 million barrels per day. In the recent years, Sri Lanka has increased its imports of oil and reduces its over-reliance on hydroelectricity.

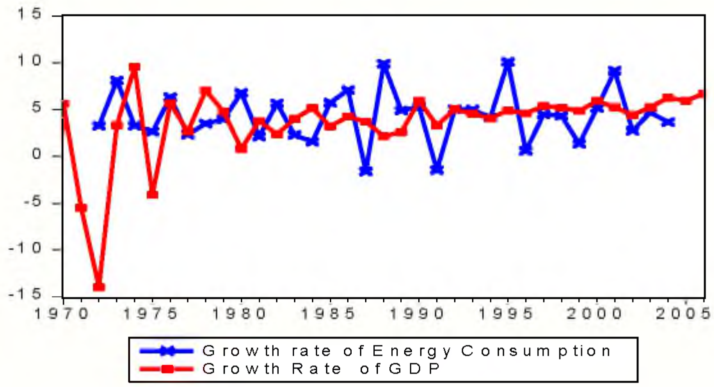
Fig. 2. Sri Lanka as the High Energy Importer Country; India as the Lower Net Energy Importer



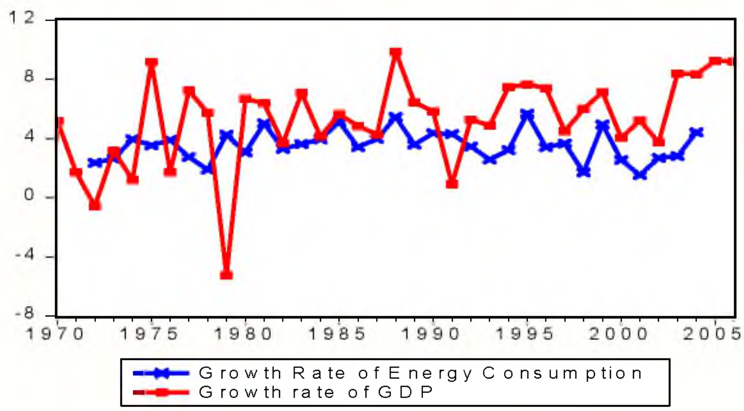
It can be argued that there is strong link between energy consumption and GDP because energy enhances the productivity of capital, labour and other factors of production [Cheng (1999)]. The relationship between energy consumption and GDP for each country is depicted in Figure 3a-d.

Fig. 3. Growth Rate of Energy Consumption and GDP

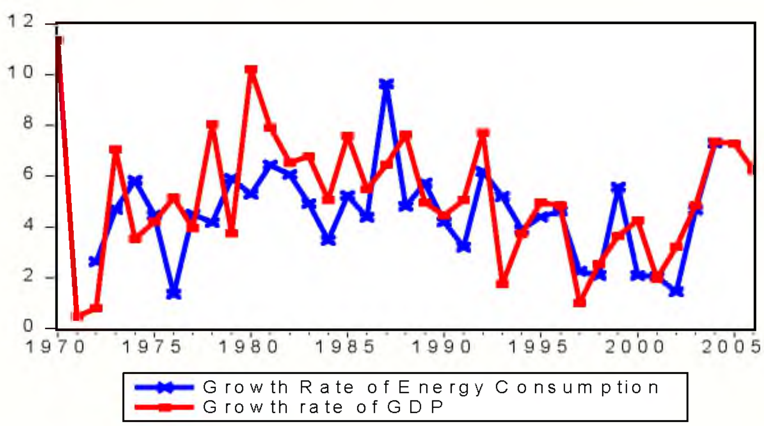
(a) Bangladesh



(b) India



(c) Pakistan



(d) Sri Lanka

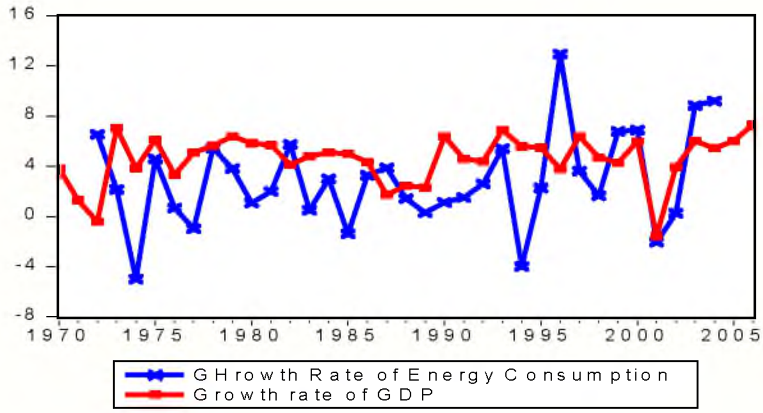


Figure 3a-d depicts the growth rate of energy consumption and growth rate of GDP in South Asia. These figures suggest that the movements in energy consumption are associated with the growth rate of GDP in each country. However, in case of India, Pakistan and Sri Lanka the growth of energy consumption is less than the growth of GDP, while energy consumption is greater than growth in Bangladesh. The movements of energy consumption and GDP imply that there is positive correlation between energy and economic growth. This can be depicted in the Table 3.

Table 3

Descriptive Statistics of Growth Rate in Energy Consumption and Growth Rate of GDP (1972–2004)

Series	Bangladesh		India		Pakistan		Sri Lanka	
	EC	GDP	EC	GDP	EC	GDP	EC	GDP
Mean	4.32	3.71	3.54	5.09	4.51	5.05	2.86	4.58
Maximum	10.13	9.59	5.67	9.86	9.64	10.22	12.96	7.06
Minimum	1.60	–13.97	1.52	–5.24	1.36	0.81	–4.98	–1.55
Std. Dev	2.79	3.85	1.04	3.02	1.77	2.21	3.76	1.93

Note: EC indicate energy consumption and GDP is gross domestic product.

The statistics presented in Table 3 suggest that the average consumption of energy vary between countries. The average growth rate of energy consumption is higher in Bangladesh as compared to India, Pakistan and Sri Lanka, while the average GDP growth from 1972–2004 is higher in India and Pakistan as compared to other countries of the region. Similarly, the movements in energy consumption are higher in Bangladesh and Sri Lanka as compared to India and Pakistan. Since, the per capita consumption of energy is much higher in Bangladesh and Sri Lanka because these countries concentrated much on energy imports (Table 2d). A sudden shock in the form of increase in energy prices in the world market brings greater volatility in the energy consumption as compared to other countries.

The correlation between energy consumption and GDP for each country is depicted in Table 4, indicate that there is strong correlation between energy consumption and GDP. This suggest that for the enhancement of GDP growth energy is pre-requisite besides the other factors of production

Table 4

Correlation between Energy Consumption and GDP

Series	Bangladesh		India		Pakistan		Sri Lanka	
	EC	GDP	EC	GDP	EC	GDP	EC	GDP
EC	1.00		1.00		1.00		1.00	
GDP	0.99	10.00	0.95	1.00	0.93	1.00	0.98	1.00

3. MODELLING OF ENERGY AND ECONOMIC GROWTH

The multivariate model is specified to avoid biased causality inferences due to the omission of relevant variables following Cheng (1999). Capital and labour are included because the neoclassical growth theory suggests the potential importance of these two variables along with energy in the growth process. Thus, the long-run relationship between real output, energy, capital stock and labour is given by:

$$y_t = a_0 + a_1 enrg_t + a_2 k_t + a_3 l_t + e_t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

Where y, $enrg$, k and l are respectively logarithms of real output, energy, capital stock and labour. Whereas, e is the error term.

The dynamic relationship between energy consumption and economic growth is specified following the modelling approach advanced by Pesaran, *et al.* (2001). Assume that

$$z_t = (y_t, enrg_t, k_t, l_t)' \;=\; (y_t, x_t)' \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

Where $x = [enrg, k, l]$

The conditional unrestricted error-correction model (UECM) for growth-energy nexus is given by

$$\Delta y_t^{\,j} = c + \pi_{yy} y_{t-1}^j + \pi_{yx.x} x_{t-1}^j + \sum_{i=1}^{k-1} \psi_i' \Delta z_{t-i}^j + \gamma' \Delta x_t^j + u_t \quad \ldots \quad \ldots \quad (3)$$

Where j is used to represents jth country (Bangladesh, India, Pakistan and Sri Lanka). The coefficients π_{yy} and π_{yx} are the long-run multipliers and c is the drift term. Lagged values of Δy and current and lagged values of Δx are used to model the short-run dynamics. The bounds test for the existence of a level relationship between y_t and x_t have the following null hypotheses:

$$H_0^{\pi_{yy}} : \pi_{yy} = 0 \,, \; H_0^{\pi_{yx.x}} : \pi_{yx.x} = 0'$$

and alternative hypotheses are correspondingly given by:

$$H_1^{\pi_{yy}} : \pi_{yy} \neq 0 \,, \; H_1^{\pi_{yx.x}} : \pi_{yx.x} \neq 0'$$

The *F*-statistic has a non-standard distribution, which depends on the unit root properties of the data that is whether variables included in the UECM are I (0) or I (1), and the number of independent variables. The critical values are available in Pesaran and Pesaran (1997) and Pesaran, *et al.* (2001). If the calculated F-stat lies above the upper bound, the hypothesis of no cointegration can be rejected and vice versa. If there is an evidence of cointegration between y_t and x_t then one can precede further using autoregressive distributed lag (ARDL) approach to examine the short-run and long-run estimates with the following specification:

$$y_t = \phi_0 + \sum_{i=1}^{k} \phi_1 y_{t-i} + \sum_{i=0}^{k} \phi_2\, enrg_{t-i} + \sum_{i=0}^{k} \phi_3 k_{t-i} + \sum_{i=0}^{k} \phi_4 l_{t-i} + \eta_t \quad \ldots \quad (4)$$

The study is based on the annual data covering the period 1970-2004. Real GDP (y_t) is used as a proxy for economic growth. Gross fixed capital formulation divided by CPI is used as proxy for capital stock (k_t). Since labour force data are not available for all the countries, hence population growth is used as proxy for labour (l_t).[4] Data on these variables are retrieved from *International Financial Statistics (IFS)* CD-ROM 2006. Energy consumption (Kilo Tone of Oil Equivalent) divided by consumer price index (CPI) is used to calculate real energy consumption ($enrg_t$). Data on this variable is retrieved from World Bank.[5]

4. EMPIRICAL RESULTS AND THEIR INTERPRETATION

Although bounds testing approach to cointegration does not require any pre-testing of unit roots. However, it is not necessary that all the series are I (0) and I (1), if any of the series are I (2) then autoregressive distributed lag (ARDL) procedure give spurious results. Hence, testing of unit root for each series is important before the implementation of ARDL cointegration method. To examine the time series properties of the data we employ augmented Dickey-Fuller (ADF) unit root test. The results are reported in Table 5.

The results reported in Table 5 suggest that except labour, other series in the case of Bangladesh are non-stationary at their level and stationary at the first difference. Labour is stationary at its level. Thus for the case of Bangladesh labour is I (0) and other series are I (1). In the case of India real GDP and labour is stationary at level, while energy and capital are non-stationary at their level and stationary at their first difference. Hence for the case of India, real GDP and labour are I (0) and all other series are I (1). In the case of Pakistan we have obtained mixed results. Energy and labour are I (0), while real output and capital are I (1). For the Sri Lanka, real GDP is I (0) and all other series are I (1) because the hypothesis of stationarity is rejected at their first difference.

Since we obtained mixed unit root results for Bangladesh, India, Pakistan and Sri Lanka. For these countries some series contains I (0) order and some I (1). Thus we implement bound testing approach in order to examine the cointegration relationship between the variables entering in Equation (1) by estimating Equation (3) for each country. The results of the bound test are reported in Table 6.

[4]See Cheng (1999, p. 41).
[5]http://devdata.worldbank.org/query/default.htm

Table 5

Results of the Unit Root Test

Series	Level	First Difference	Decision
	Bangladesh		
y_t	–0.49 (0)	–7.90(0)*	I (1)
$enrg_t$	–2.18 (1)	–8.67 (0)*	I (1)
k_t	–1.44 (1)	–4.86 (1)*	I (1)
l_t	–4.75 (0)*	–2.45 (0)***	I (0)
	India		
y_t	–3.99 (0)*T	–6.01 (0)*T	I (0)
$enrg_t$	–0.93 (1)	–6.58 (0)*	I (1)
k_t	–2.06 (1)	–4.48 (0)*	I (1)
l_t	–7.12 (0)*	2.36 (0)	I (0)
	Pakistan		
y_t	–2.34 (1)T	–4.72 (1)*T	I (1)
$enrg_t$	–2.91 (0)***	–3.64 (1)**	I (1)
k_t	–2.06 (1)	–4.62 (0)*	I (1)
l_t	–5.04 (0)*	–1.71 (0)	I (0)
	Sri Lanka		
y_t	–3.26 (1)**	–4.92 (1)*	I (0)
$enrg_t$	–1.55 (0)	–4.10 (0)*	I (1)
k_t	–2.80 (0)	–3.37 (1)**	I (1)
l_t	–0.17 (2)	–3.42 (3)***	I (1)

Note: 95 percent critical value with constant is –2.9472 and with trend are 3.5426 respectively. Number of lags is given in parentheses and Akaike Information Criterion is used for lag selection. *, ** and *** indicate significant at the 1 percent, 5 percent and 10 percent level respectively. T stands for intercept and trend.

Table 6

Results of the Bound Test to Cointegration

Country	Variables Included	Number of Lags	F-Statistic	Decision
Bangladesh	$(y_t \backslash enrg_t, k_t, l_t)^a$	1	6.00	Cointegration
India	$(y_t \backslash enrg_t, k_t)^b$	2	8.74	Cointegration
Pakistan	$(y_t \backslash enrg_t, k_t, l_t)^c$	1	8.41	Cointegration
Sri Lanka	$(y_t \backslash enrg_t, k_t, l_t)^d$	2	4.54	Cointegration

Note: The number of lags is selected on the basis of Akaike Information Criterion (AIC). The critical values are given by Pesaran, *et al.* (2001).

a= no constant, unrestricted trend and number of regressor k=3.

b= no intercept, unrestricted trend and number of regressor k=2.

c= unrestricted intercept, unrestricted trend and number of regressor k=3.

d= no intercept, unrestricted trend and number of regressor k=3.

The bound test results reported in Table 6 suggest that for all countries the hypothesis of no cointegration is rejected at the 5 percent level of significance. The existence of cointegration suggests that energy, capital and labour plays an important role in enhancing output in these countries.

Given the evidence of cointegration between real output, energy consumption, capital and labour, we now employ autoregressive distributed lag (ARDL) method to examine the long-run and short-run relationship between real output, energy consumption, capital and labour by estimating Equation (4). The long-run and short-run results for each country are reported in Table 7.

Table 7

Long-run and Short-run Estimates of Energy and Real Output

Bangladesh	**Long-run Estimates**
	$y_t = 0.12 enrg_t + 0.04 k_t + 0.29 l_t + 0.04 trend$
	$(5.05)^{*}$ (1.56) $(8.43)^{*}$ $(11.33)^{*}$
	Short-run Estimates
	$\Delta y_t = 0.08 \Delta enrg_t + 0.03 \Delta k_t + 0.21 \Delta l_t + 0.03 \Delta trend - 0.70 Ecm_{t-1}$
	$(4.31)^{*}$ (1.53) $(4.69)^{*}$ $(5.29)^{*}$ $(-6.01)^{*}$
	$\bar{R}^2 = 0.55$ $F-stat = 10.15$
	$S.E = 0.02$ $DW-stat = 2.36$
India	**Long-run Estimates**
	$y_t = 0.26 enrg_t + 0.66 k_t + 0.02 trend$
	$(5.53)^{*}$ $(2.62)^{**}$ (1.31)
	Short-run Estimates
	$\Delta y_t = 0.40 \Delta enrg_t + 0.21 \Delta k_t + 0.008 \Delta trend - 0.32 Ecm_{t-1}$
	$(4.33)^{*}$ $(3.83)^{*}$ (0.97) $(-3.04)^{*}$
	$\bar{R}^2 = 0.73$ $F-stat = 28.53$
	$S.E = 0.02$ $DW-stat = 2.14$
Pakistan	**Long-run Estimates**
	$y_t = 2.97 + 0.40 enrg_t + 0.21 k_t - 1.05 l_t + 0.09 trend$
	$(2.20)^{*}$ $(4.84)^{**}$ $(3.85)^{*}$ $(-2.81)^{**}$ $(7.77)^{*}$
	Short-run Estimates
	$\Delta y_t = 2.03 \Delta Inpt + 0.27 \Delta enrg_t + 0.30 \Delta k_t + 4.05 \Delta l_t + 0.06 \Delta trend - 0.68 Ecm_{t-1}$
	$(2.28)^{**}$ $(2.81)^{**}$ $(6.58)^{**}$ $(3.41)^{*}$ $(3.88)^{*}$ $(-3.90)^{*}$
	$\bar{R}^2 = 0.68$ $F-stat = 14.82$
	$S.E = 0.02$ $DW-stat = 1.84$
Sri Lanka	**Long-run Estimates**
	$y_t = 0.22 enrg_t + 0.22 k_t + 2.06 l_t + 0.02 trend$
	$(3.07)^{*}$ $(6.52)^{*}$ $(10.03)^{*}$ $(2.39)^{**}$
	Short-run Estimates
	$\Delta y_t = 0.30 \Delta enrg_t + 0.04 \Delta k_t + 1.38 l_t + 0.01 \Delta trend - 0.70 Ecm_{t-1}$
	$(2.84)^{*}$ (0.91) $(3.98)^{*}$ $(2.15)^{*}$ $(-4.22)^{*}$
	$\bar{R}^2 = 0.62$ $F-stat = 9.76$
	$S.E = 0.03$ $DW-stat = 1.93$

* and ** indicate significant at the 1 percent and 5 percent level of significance.

(i) *Bangladesh*

The results reported for Bangladesh suggest that energy, capital and labour exerts positive impact on real out put. However, the relative impact of labour and capital is more on the real output. The coefficient of energy is equal to 0.12 which is low as compared to the coefficient of labour (i.e. 0.29) but higher than the coefficient of capital (i.e. 0. 04) in the long-run. The short-run effect of energy growth is significant and more in terms of size as compared to capital, while the short-run impact of energy is less than that of labour. This implies that in the short-run labour and energy are the key factors playing a dominant role in enhancing economic growth in Bangladesh. The error-correction coefficient is –0.70 which is highly significant suggesting the existence of long-run causality running from energy to economic growth. Furthermore, the short-run coefficient of energy is positive and significant indicating the presence of causality running from energy to economic growth. This result has important policy implications for Bangladesh because economy of Bangladesh is energy dependent and the shortage of energy adversely effects its economic growth and employment. Presently, Bangladesh faces shortage of energy. In the year 2004 its demand for energy is equal to 22789 (KTOE) while supply is equal to 18390 (KTOE) and the shorted is 4399 (KTOE). To meet this shortfall, Bangladesh's net imports of energy are equal to 19.3 percent of total energy use (Table 2 a-d).

(ii) India

In the case of India both energy and capital are positively related to real output in the long run.[6] However, capital is the dominant factor in determining the output in the long-run as indicated by the size of the coefficients of the energy and capital. However, in the short-run energy exerts positive and strong effect on growth. The relative impact of energy consumption is more than that of capital. The key ingredients of economic growth in India are the energy and capital. Surprisingly labour plays no role in the process of economic growth in India. This result is consistent with the findings of Cheng (1999). The error-correction term is negative and significant supporting the evidence of long-run causality between economic growth and the energy. The coefficient of energy is positive and significant in the short-run also support the presence of short-run causality between energy and growth. This result suggests that Indian economy is heavily dependent on energy. In fact the gap between energy consumption and energy production consistently increasing (see Figure 2b and Table 2 a-d).

(iii) Pakistan

The results suggest that both energy consumption and capital exerts positive impact on real output. The relative effect of energy is higher. This result suggests that real GDP and energy consumption are significantly interrelated and the shortage of energy may retard economic growth process in Pakistan. Surprisingly labour effects real output negatively in the long-run. This could be due to the large proportion of old and under-age population not able to work. Although labour play a significant role in the Pakistan's economic development but the large share of children and old peoples offset the positive effects of labour on growth.

[6]During the estimation process we find that the variable labour is insignificant so we drop this variable from the analysis.

In the short-run energy, capital and labour play positive role in boosting real output. The coefficient of energy (0.27) is relatively low as compared to the coefficient of labour (0.87) and capital stock (0.30), implying that labour plays dominant role in the process of development in the short-run. This result has very important implications for Pakistan. Pakistan may reconsider its employment policy and concentrates not only on the development of energy sector but also take necessary measures to improve the quality of labour force. Our results are consistent with the earlier findings of Siddiqui (2004) in terms of positive association between economic growth, growth in energy consumption, growth in labour and growth in capital stock. The error-correction coefficient is negative and significant supporting the evidence of long-run causality between real output, energy consumption and other factor entering in the model. The causality is running from energy to real output. The significance of the coefficient of energy consumption in the error-correction equation implies the existence of causality running from energy consumption to real output in the short-run. Thus, in order to enhance economic growth the authorities needs to further develop the energy sector and improve the quality of labour force.

(iv) Sri Lanka

We also find positive evidence with respect to the relationship between real output and energy consumption and capital and labour. The impact of labour is higher than the impact of energy and capital on real output in the long-run. In the short-un energy and labour growth play significant role in the promotion of domestic productivity. The significance of the error-correction term and the energy consumption coefficients in the error-correction equation supports the evidence of long-run as well as short-run causality between growth and energy consumption. Thus, development of the energy sector is very vital for the enhancement of economic growth in Sri Lanka.

From the empirical analysis we can draw the following general conclusions:

- Energy consumption in South Asian countries seems to play an important role in determining economic growth.
- There is evidence of long-run as well as short-run causality between energy consumption and real GDP.
- The error-correction term for all countries remains significant, however, the size of this coefficient vary from 0.70-0.32 (in absolute term) depending on the economic structure and stages of domestic market development.

5. CONCLUSIONS

South Asian countries have facing the problem of energy shortage and the gap between energy consumption and energy production is persistently increases over time. This growing gap between demand for and the supply of energy is expected to retard the economic growth in these countries. Keeping in mind the vital and critical role of energy in the process of development, this study has developed the link between energy consumption and real output for four South Asian countries including Bangladesh, India, Pakistan and Sri Lanka. The study is based on annual data covering the period 1972-

2004[7] and bound testing procedure is used to investigate the cointegration relationship. Bound test supports the evidence of cointegration among the real output, energy, capital and labour. To examine the long-run and short-run impact of energy on real output autoregressive distributed lag (ARDL) technique is employed. The results based on the long-run analysis suggest that energy consumption play an important role in enhancing productivity in all the countries. To determine the long-and short-run causality among the energy consumption and output, we have estimated short-run error-correction model for each country. The results support the evidence of causality running from energy consumption to GDP in all the countries in the long-as well as in the short-run. On the whole, results suggest that the economy of each country is energy dependent and shortage of energy may negatively affect the economic growth which eventually results in a fall in income and employment.

The important policy implications drawn from this study are that in order to achieve rapid economic growth, South Asian countries may adopt a policy of energy sector development on priority basis. Besides the energy sector development, Pakistan may take care of labour force up-gradation through the changes in labour composition and acceleration of capital formation. In India labour plays no or little role at all in the development process. Hence, India should take necessary measures to utilise cheap and surplus labour in most efficient way in the process of development besides the development of the energy sector. Bangladesh and Sri Lanka should accelerate their rate of capital accumulation. Finally these countries may pursue energy conservation policies in such a way that these policies may not produce adverse affects on economic growth.

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