TEH LOG-RUN EQUILIBRIUM RELATIONSHIP BETWEEN CARBON DIOXIDE EMISSIONS AND GROSS DOMESTIC PRODUCT IN SRI LANKA

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Introduction

Sri Lanka plans to invest heavily on coal-based electricity in the future (CEB, 2008). Fossil fuel consumption in the transport sector is likely to increase with the rising standard of living resulting from economic growth. These factors might lead to significant increase in Sri Lanka's future CO_2 emissions. If CO_2 emissions and economic growth, proxied by gross domestic product (GDP), is tied up in a long-run equilibrium then continual economic growth in Sri Lanka could be hampered in a world that is taking serious steps to reduce its greenhouse gas emissions. The focus of this study is to investigate the existence or the absence of a long-run relationship between Sri Lanka's CO_2 emissions and her GDP, since the existence of which testifies the presence of a causal link between CO_2 emissions and GDP. Residual-based tests for cointegration in models with regime shifts are used (Gregory and Hansen, 1996a; 1996b).

Data Analyses

Data used for model development are the time series on CO_2 emissions stemming from fossil-fuel burning, cement manufacture and gas flaring (in kilo tonnes of CO_2) and GDP (in billions of constant 2002 Sri Lankan Rupees) obtained from World Bank Group (2009) for the period 1960 to 2005. The Dickey-Fuller and Phillips-Perron unit root tests established that the series are integrated to order one.

Econometric Methodology

A linear relationship between CO_2 emissions and GDP allowing for a single structural change may be modelled, following Gregory and Hansen (1996a), as follows:

$$C(t) = \alpha_1 + \alpha_2 DU_t + \beta_1 G(t) + \beta_2 G(t) DU_t + \lambda_1 t + \lambda_2 t DU_t + e(t) \quad (1)$$

where C and G represent the natural logarithms of CO_2 emissions and GDP, respectively, t is the time in years, α_1, β_1 and λ_1 are the intercept, slope coefficient and trend coefficient, respectively, before the regime shift, α_2, β_2 and λ_2 are the corresponding changes after the regime shift, $DU_t = 1(t>T_B)$ is the dummy, T_B is the unknown break year of the regime shift and $e(t)$ are the residuals.

In the residual-based tests for cointegration in models with regime shifts, (1) is estimated at an assumed break year using the ordinary least square (OLS) procedure and residuals of which is used to calculate the corresponding augmented Dickey-Fuller (ADF) statistic at an automatically chosen lag value for a specified maximum lag value. The year at which the ADF statistic takes the smallest value is taken as the year of regime shift and this value of the ADF statistic is tested against the critical values provided in Gregory and Hansen (1996a; 1996b) to reject/accept the null of no cointegration.

Results and Discussion

Results of the residual-based tests for cointegration in models with different kinds of regime shifts proposed by Gregory and Hansen (1996a; 1996b) are tabulated in Table 1. Comparison of the test statistics with the critical values reveals the null of no cointegration cannot be rejected in GH-I and GH-II which incorporate only the level shift. For the models incorporating the regime shift, the null of no cointegration is rejected at 5% level of significance in GH-IV and at 10% level of significance in GH-III and GH-V.

Coefficients of the models estimated at the identified break years (provided in Table 1) are tabulated in Table 2, which reveal all estimated coefficients of GH-III are statistically significant with the expected signs and magnitudes. Therefore, we choose GH-III to represent the following long-run equilibrium relationship between CO_2 emissions and GDP in Sri Lanka:

$$C(t) = 5.061 - 7.506DU_t + 0.491G(t) + 1.078G(t)DU_t + e(t) \quad (2)$$

where $DU_t = 1(t > 1984)$ and $e(t)$ is the error-correction term used in estimating the short-run dynamic relationship given below:

$$\Delta C(t) = -\underset{[-3.86]}{0.499}\hat{e}(t-1) + \underset{[2.83]}{0.876}\Delta G(t) + \varepsilon(t) \quad (3)$$

for which the adjusted R^2 is 27.0%, the Durbin-Watson statistic is 1.79 and the residuals statistics supports the statistical significance of (3).

Conclusion

Long-run equilibrium relationship of (2) reveals that 1% increase in the real GDP led to about 0.5% and 1.5% increase in CO_2 emissions before and after the regime shift at 1984, respectively. The coefficient of the error-correction term in (3), known as the adjustment parameter, has the desired negative sign and is highly significant with the t-statistic of -3.86. Therefore, it is evident that any deviation caused by the short-run dynamics is corrected by about 50% in a year. Moreover, in the short-run, the real GDP growth and emissions growth are strongly related with 1% increase in real GDP growth causing about 0.87% increase in the emissions growth.

According to the Central Bank of Sri Lanka, the annual real GDP growths in Sri Lanka were 7.5, 6.8, 6.0 and 3.5% during 2006 to 2009 and the real GDP growth projections are 6.5, 7.5, 8.0 and 8.0 in 2010, 2011, 2012 and 2013. When using these real GDP growths since 2005 and an assumed average annual real GDP growth of 6% since 2014, the model developed in this study predicts 1150% and 3020% increase in CO_2 emissions by 2020 and 2030, respectively, relative to the 1990 level. It means the CO_2 emissions stemming from the burning of fossil fuel and cement manufacture, in the business-as-usual scenario without any serious policy change, will be increased from 0.6 tonnes of CO_2 per capita in 2005 to 2.3 and 5.6 tonnes of CO_2 per capita in 2020 and 2030, respectively (under the median range population growth scenario). However, with the planned increase of coal power contribution to grid electricity from zero today to 3,155 MW in 2022 (CEB, 2008), it is highly likely that CO_2 emissions in Sri Lanka surpass the above forecasted values.

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Table 1. Test statistics obtained with the residual based tests for cointegration with regime shifting models

Model	Break year	Test statistic
GH-I: Level shift only; $\beta_2 = \lambda_1 = \lambda_2 = 0$ in equation (2)	1996	-3.661
GH-II: Level shift with trend; $\beta_2 = \lambda_2 = 0$ in equation (2)	1996	-3.749
GH-III: Regime shift; $\lambda_1 = \lambda_2 = 0$ in equation (2)	1984	-4.717*
GH-IV: Regime shift with trend; $\lambda_2 = 0$ in equation (2)	1984	-5.444**
GH-V: Regime and trend shift	1984	-5.373*

Note: * and ** denote $p<0.1$ and $p<0.5$, respectively. Test statistics are compared with the asymptotic critical values of Gregory and Hansen (1996a; 1996b). Following Narayan (2005) and Rao and Kumar (2009), same critical values are used for GH-III and GH-IV.

Table 2. Coefficients of the cointegrating equations estimated at the identified break years, respectively, and their corresponding t-statistics (in the brackets)

Model	α_1	α_2	β_1	β_2	λ_1	λ_2
GH-I	5.156 (16.5)	0.525 (7.2)	0.473 (9.6)	-	-	-
GH-II	-2.014 (-0.41)	0.514 (7.0)	1.765 (1.99)	-	-0.058 (-1.45)	-
GH-III	5.061 (11.1)	-7.506 (-9.1)	0.491 (6.6)	1.078 (8.9)	-	-
GH-IV	-3.973 (-0.99)	-7.449 (-9.5)	2.119 (2.95)	1.071 (9.2)	-0.073 (-2.28)	-
GH-V	-6.089 (-1.15)	-2.485 (-0.31)	2.501 (2.63)	0.175 (0.12)	-0.090 (-2.12)	0.040 (0.61)