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**GROWTH EMPIRICS: STRUCTURAL
TRANSFORMATION AND SECTORAL
INTERDEPENDENCIES OF
SRI LANKA**

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Abstract

Even though the impacts of the globalization on economic growth and structural changes are inevitable, many developing countries are slowly transformed in the process. This paper examines the impact of structural transformation of Sri Lanka's economy on sectoral interdependencies to provide evidence for policy making. It advocates policies, investigating the relationship among agricultural, industrial, and service-related gross domestic products (GDPs) under (i) an open economic policy setting, (ii) different government policy regimes, and (iii) major policy eras from 1950 to 2015. The analysis uses secondary data from the Central Bank of Sri Lanka and the Institute of Policy Studies publications. A time-series econometric method, vector autoregression, was used including causality analysis, and Gregory-Hansen cointegration, for estimating a long-run relationship in sectoral growth. The empirical investigations revealed an existence of unidirectional causality toward agricultural to industrial GDP, and bidirectional causality between agricultural and service GDPs in terms of Sri Lanka's economy. The effect of Gregory-Hansen co-integration affirmed a long-run nexus in agricultural growth positively with industrial and service growth. Apart from that, the evidence of structural change through open economic policies depicted a significant impact between pre-open economic and post-open economic policies for a drastic economic growth even under structural break. Although none of the policy regimes have prejudiced economic growth, reforms can be initiated to ascertain the revival of economic growth, and promoting service sector-related economic systems are desirable with reforming policies.

Keywords: structural transformation, growth, open economy, vector autoregression, cointegration

JEL Classification: C01, C22, H50, O11, Q18, Q28

Contents

1. INTRODUCTION

Globalization brought up ample opportunities and remunerations to the world in terms of technological advancement and liberalization of trade and capital markets, but many developing countries lag in integrating with the world economy. However, economic growth has been revolutionized drastically under the consequences of globalization during the last few decades; many developing economies are still under the lower rate of agricultural growth. The consequences are similar in Sri Lanka. Even though the agriculture sector has been expanded, the contribution from the agriculture sector to the aggregate gross domestic product (GDP) is declining significantly (Figure 1). Though it is considered the growth engine, agricultural growth has been declining to less than 10% of the national GDP.

Based on the adoption to the policies, structural change of the economy is unavoidable. Accordingly, the productivity of the sectoral growth change affects the total economic growth and the sectoral growth independently. The growth empirics phenomenon allows investigating the structural change of Sri Lanka using empirical methods to understand the long-run nexus of sectoral growth and their interdependencies within the economy.
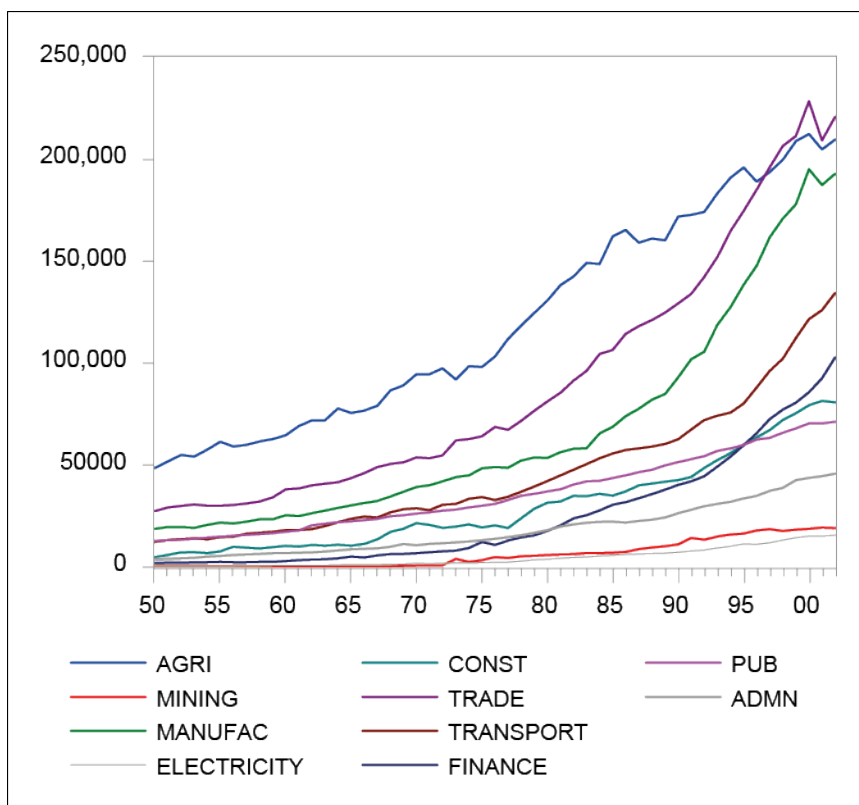
Figure 1: Sectoral Growth during 1950–2015
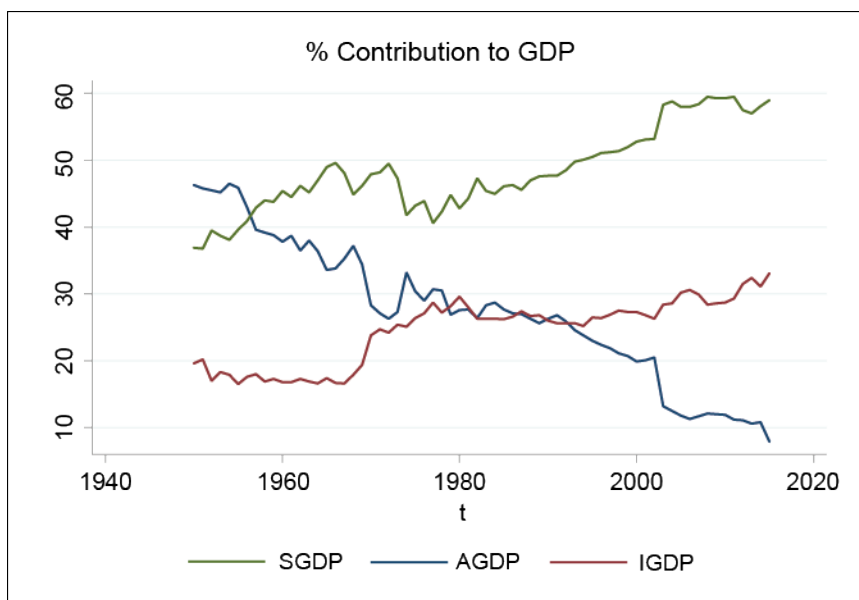
AGDP = agricultural gross domestic product, IGDP = industrial gross domestic product, SGDP = service gross domestic product.

Source: Central Bank of Sri Lanka.

Figure 2: Sub-Sectoral Growth for 1950–2015

Source: Central Bank of Sri Lanka.

Though substantial research has been conducted to examine the problem of agricultural growth stagnation in numerous approaches, limited pragmatic evidence is available to explore the changes of structure on economy with the policy dynamics of Sri Lanka. This paper contributes to the literature by bridging the knowledge gap and providing a recently developed econometric application of Gregory-Hansen (GH) cointegration and Vector Error Correction Models (VECM) for sectoral growth in policy implications. The investigation advocates the open economic policies and the historical review of reforms in agricultural policies in Sri Lanka. Limited economic evidence is supported to understand the policy adjustment process in Sri Lanka, although numerous discussions and forums have been conducted through political approaches, especially focusing on agricultural growth. This paper attempted to serve the purpose through agricultural development policies on sectoral growth and development policy diversions.

This paper is organized as follows: first, a study context of the historical review of policy regimes is presented, which is followed by growth empirics and empirical method. The next section presents the estimates of results. The results and discussion section presents analytical results and policy determinations. The final section includes conclusion and policy implications.

2. HISTORICAL REVIEW OF POLICY REGIMES

Sri Lanka's policy changes in line with globalization made numerous influences on agricultural growth. The historical time frame can be divided into three basic periods: food self-sufficiency era (1948–1977), open economic policy era I (1977–1994), and open economic policy era II (1994–present). During these time frames, different policy implications were introduced in various disciplines embedded in development administration, which includes land, water, credit, trade, marketing, food, and other sectors. These are the most pressing sectors that nexus agricultural changes and the economic development of the country.

The Government of Sri Lanka focuses on rebuilding and encouraging economic growth through policy administration under different policy changes. In food self-sufficiency era (1948–1977), land policies were imposed to achieve food self-sufficiency, which included Paddy Lands Act (1958) and Land Reform Law (1972), which was extended to cover public land in 1976. Agricultural Productivity Law (1972), and Agrarian Service Act (1979). Other than land laws, policies related to water included the Mahaweli Development Board Act, which was initiated under the Mahaweli development project in 1970. Moreover, the credit as a development facilitating factor, the government established the Peoples' Bank (1963), new agriculture credit scheme (1967), and comprehensive rural credit scheme (1973); trade restrictions were also imposed on the import of high-value crops (chilies, potato, onions) (1960s), and there was a complete ban on the imports of a range of consumer goods (1970). Marketing policies, such as guaranteed price scheme for paddy (1948), Paddy Marketing Board (PMB) in 1972, and guaranteed price for farmers increased by 40%, were also implemented. Finally, food policies were most vital dynamics in the era with following changes:

- food subsidy scheme through a rice ration in 1948;

- size of the basic rice ration scheme was reduced by one-half pound per household in 1952;

- phasing out of the subsidy scheme resulting in 300% price increase rice ration in 1953;

- consumer-oriented food policy: reduction of rice and sugar prices, basic ration was cut by one half and issued free of charge in 1966;

- size of the rice ration was restored to four pounds in 1970; and

- basic ration was reduced by 50% due to world food shortage and high cost of imports intensified efforts to increase the domestic production in 1973.

In the open economic policy era I (1977–1994) and era II (1994–2007), land policies were imposed, for instance, lands grants, leasing out some 24,000 acres of land in the Mahaweli area to a foreign company for oil palm cultivation, and 8,000 acres to sugar production (1980), and Land Development (Amendment) Act (1981). Water policies administrated by the government included the Mahaweli Authority of Sri Lanka established by Act of Parliament (1979) with privatization of irrigation water (1980), cabinet approval for a nationwide water charge programme (1983), agrarian service act was amended in a way that farmers' organizations to collect irrigation service fees, participatory irrigation system management (1980), capital-intensive Mahaweli river development project (1988) rice-based irrigation, land development, and settlement programs (Central Bank of Sri Lanka, 1990). Further, credit facilities applied as a policy concerns such as:

- thrift and credit co-operative societies (SANASA Movement, 1978);

- the new comprehensive rural credit scheme (1986);

- perennial crop development project (1988);

- introduction of *'Praja Naya Niyamaka'* (1988);

- and establishment of national development bank.

In addition to that, the trade policies were finest concerns of the government through the globalization, in which the economy was opened:

- many of the government controls were abandoned (1977),

- public sector import monopolies except for some commodities (e.g. rice) were eliminated (1977);

- import tariffs were reduced, the use of import licensing and quotas was almost abandoned (1977);

- financial sector was liberalized (1977);

- foreign export controls were dismantled (1977);

- new export processing zones or free trade zones were established (1977);

- tariff commission was established and export duties were phased out completely (1985);

- rice import by private sector was authorized—yearly quota for rice and government license for imports (1988);

- duty on rice imports were imposed (1988); and

- public sector import monopolies for sugar and milk powder were eliminated (1988).

Finally, marketing also supported trade policies such as:

- elimination and reduction of price controls on few selected commodities (1977);

- guaranteed price scheme for PMB-paddy and 14 subsidiary food crops to stabilize product price, department of marketing;

- purchase of agricultural produce from farmers by sugar corporations (1988); and

- security price scheme to stabilize prices of minor export crops (1992–93) (Central Bank of Sri Lanka 1994).

3. GROWTH EMPIRICS LITERATURE

The growth theory has been renewed with the new dimensions of empirical methods on economic growth. Even though the main emphasis in the literature is to identify the determinants of economic growth, limited effort has been given on sectoral growth and their interdependencies in the individual economy. The study of growth empirics through sectoral growth evolved from the dual economic model (Lewis 1954, Fei and Ranis 1961). The seminal study of Lewis (1954) and of Fei and Ranis (1964) set a strand of the growth literature to model the development process with regard to structural transformation. The dual economy model predicts the agriculture sector as the basis of an evolving economy that is an engine of the capital need for beginning toward the second stage of economic development through industrialization. The evidence has been taken in growth empirics in African countries and found long-run nexus and short-run causality among the industry, agriculture, and service sectors under the neoclassical growth theories (Blunch and Vemer 1999). The empirical proofs of the sectoral interdependencies among the agriculture, industry, and service sector are contemplated because agriculture is allocated a lower interdependence (Chenery and Watanabe 1958, Hirschman 1961). Therefore, agriculture is viewed as providing both demand and supply-side interrelationship to industry and services. Hwa (1989) hypothesizes that, all other factors held constant, faster agricultural GDP growth causes earlier growth in the industry sector. Gemmell (1982), Bhagwati (1984), and Dowrick (1990) model the behavior of service activities of the economic growth and its relationship to the industry sector, but now a number of evidence for the empirical process exist. However, some empirical studies have identified interrelationships involving service activities are recognized (Fuchs 1968, Blades et al. 1974, Gemmell 1982, Bhagwati 1984).

This paper focuses on providing pragmatic evidence to quantify these inter-sector dynamics since the development underlines excessive degree of interdependence between the agriculture and industry sector in Sri Lanka's economy (Figure 1). This paper is generally about identifying inter-sector dependencies with empirical evidence on agricultural growth to facilitate economic development policies.

Structural Transformation and Agricultural Growth

Structural transformation is defined as the reallocation of economic activity across three broad sectors (agriculture, manufacturing, and services) that accompany the process of modern economic growth. Agricultural transformation in Sri Lanka will likely take place according to past trends, though the pace and direction of change will depend on emerging challenges and opportunities related to environmental stress, market instability, future technological breakthroughs, and the rise of global value chains. Over the next 2 decades, many countries of developing Asia will move on to the next phase of agricultural development (Briones and Felipe 2013). However, the reduction in agriculture's employment share will continue to lag, relative to the decline in its output share. The comparison between the South Asian countries in terms of changes in employment and sectoral shares is shown in Table 1 and 2 respectively.

Comparative Analysis of Changes of Employment Share and Output Share

Table 1: Changes of Employment Share and Output Share

Country	Period Covered (OS – Longest Available)	OS Start; End (%)	Speed of Reduction OS (% per annum)	Period Covered (Same for OS and ES)
Bangladesh	1980–2010	31.6; 18.6	1.70	1984–2005
India	1960–2010	42.8; 19	1.58	1994–2010
Nepal	1965–2010	65.5; 36.1	1.29	1991–2001
Pakistan	1960–2010	46.2; 21.2	1.52	1980–2008
Sri Lanka	1960–2010	31.7; 12.8	1.76	1981–2009

Country	OS Start; End (%)	Speed of Reduction OS (% per annum)	ES Start; End (%)	Speed of Reduction ES (% per annum)
Bangladesh	32.3; 20.1	2.13	58.8; 48.1	0.91
India	28.5; 19	2.36	61.9; 51.1	1.12
Nepal	47.2; 37.6	2.05	81.2; 65.7	1.91
Pakistan	29.5; 20.3	1.28	52.7; 44.7	0.57
Sri Lanka	27.7; 12.7	2.65	45.9; 32.6	1.17

ES = agriculture's employment share, OS = agriculture's output share.
Source: R. Briones and J. Felipe (2013).

Table 2: Changes of Sectoral Share in South Asian Countries

Country/Year	Agriculture (% of GDP)			Industry (% of GDP)			Services (% of GDP)		
	2000	2010	2013	2000	2010	2013	2000	2010	2013
Bangladesh	25.5	17.8	16.3	25.3	26.1	27.6	49.2	56	56.1
Bhutan	27.4	17.5	NA	36.0	44.6	NA	36.6	37.9	NA
India	23.4	18.2	18.4	26.2	27.2	24.7	50.5	54.6	57
Maldives	NA	4.1	3.9	NA	14.9	14.5	NA	81	81.6
Nepal	37.8	35.4	33.9	17.3	15.1	15.2	44.9	49.5	51
Pakistan	25.9	24.3	25.1	23.3	20.6	21.1	50.7	55.1	53.8
Sri Lanka	17.6	12.8	10.8	29.9	29.4	32.5	52.5	57.8	56.8
Afghanistan	38	28.8	25	24	21.3	22	38	49.8	54

Note: GDP = Gross Domestic Product, NA = Not Available.
Source: ADB (2014).

4. DATA

Secondary data on the sectoral GDPs from 1950 to 2015 from Central Bank of Sri Lanka and Institute of Policy Studies publications are used. The disaggregated sectoral GDPs on agriculture, industry, and service were used after transformation into natural logarithm of the GDPs.

5. EMPIRICAL METHOD

A. Unit Root Test without Structural Break

The unit root test explores the stationarity of the time series data. The Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests were applied to probe the stationary behavior of the time series data (Dickey and Fuller 1979, Phillips 1987, Phillips and Perron 1988). The ADF test can be estimated as

$$\Delta y_t = \delta_0 + \delta_1 y_{t-1} + \delta_2 t + \sum_{i=1}^{n} \varphi_i \Delta y_{t-1} + \varepsilon_t \tag{4}$$

where D is the difference operator, y is the logarithm of the series, t is a trend, δ and φ are the parameters to be estimated, and e is the error term.

B. Unit Root Testing with Trend Break Hypothesis

Perron's (1989) analysis of unit roots in series with trend break is, based on the null hypothesis, that it has a unit root with possibly nonzero drift against the alternative that the process is trend stationary. He finds that the estimation of equation (9) would have low power in rejecting the null of unit root, even if they are estimated for samples split based on an exogenous change in slope or intercept. For this purpose, he has clearly explained the models under the null and alternative hypotheses as follows:

Null Hypotheses:

$$\text{Model A: } y_t = \alpha_1 + \delta y_{t-1} + \beta D(TB)_t + \varepsilon_t \tag{5}$$

$$\text{Model B: } y_t = \alpha_1 + \delta y_{t-1} + (\alpha_2 - \alpha_1)DU_t + \varepsilon_t \tag{6}$$

$$\text{Model C: } y_t = \alpha_1 + \delta y_{t-1} + \beta D(TB)_t + (\alpha_2 - \alpha_1)DU_t + \varepsilon_t \tag{7}$$

Alternative Hypotheses:

$$\text{Model D: } y_t = \alpha_1 + \beta_1 t + (\alpha_2 - \alpha_1)DU_t + \varepsilon_t \tag{8}$$

$$\text{Model E: } y_t = \alpha_1 + \beta_1 t + (\beta_2 - \beta_1)DT_t + \varepsilon_t \tag{9}$$

$$\text{Model F: } y_t = \alpha_1 + \beta_1 t + (\beta_2 - \beta_1)DT_t + (\alpha_2 - \alpha_1)DU_t + \varepsilon_t \tag{10}$$

where DT_{t*} =t-TB and DT_t =t if t>TB and 0 otherwise.

DU_t =1 if t>TB, 0 otherwise.

$D(TB)_t$ =1 if t=TB+1, 0 otherwise.

A(L) ε_t =B(L) v_t

Subscript 1 on the coefficients denotes those of pre-trend break (TB) and subscript 2 denotes those of post-trend break (TB). By definition, the coefficient on DU_t captures the change in intercept, the one on DT_{t*} captures the change in trend alone, and that on DT_t captures the change in trend, when change in intercept also co-occurs. Significance of any of these would mean that there has been a change of the corresponding kind after the hypothesized trend break.

Vector Autoregression Specification

A Vector Autoregression (VAR) is a model that K variables are specified as linear functions of p of their own lags, p lags of the other K-1 variables, and, possibly, additional exogenous variables. A p-order vector autoregressive model, composed VAR (p), with exogenous variables x_t is derived as

$$x_t = \prod_1 x_{t-1} + \mu + \varepsilon_t \tag{1}$$

A VAR framework is appealing because it permits the data to determine the robust model specification and considers variables as endogenous. Thus, a general polynomial distributed lag framework or VAR (k) model can be defined as

$$x_t = \prod_1 x_{t-1} + \prod_2 x_{t-2} + ... + \prod_k x_{t-k} + \mu + \varepsilon_t \tag{2}$$

with an equilibrium-correcting form such that,

$$\Delta x_t = \Gamma_1 \Delta x_{t-1} + ... + \Gamma_{k-1} \Delta x_{t-k} + \prod x_{t-k} + \mu + \varepsilon_t \tag{3}$$

where $t=1,....T$; vector of independent variables that are linear functions of past values of and is an (nx1) vector of constants such that ε_t, an (n ´1) vector of independently distributed disturbances of zero mean and diagonal variance–covariance matrix Ω, i.e. ε_t ~ n.i.d.(0, Ω).

Vector Autoregression Diagnostics and Inference

Because fitting a VAR of the correct order is vital, *Order Selection Criteria* offer several methods for choosing the lag order p of the VAR to fit. After fitting a VAR, and before proceeding with inference, interpretation, or forecasting, checking that the VAR fits the data is important. *Lagrange Multiplier Test* can be used to check for autocorrelation in the disturbances. *VAR Wald tests* help to determine whether certain lags can be excluded. *Normality* tests the null hypothesis that the disturbances are normally distributed. *Stability* checks the eigenvalue condition for stability, which is needed to interpret the impulse–response functions and forecast-error variance decompositions. *Unit Root Test;* the test can be used to identify the stationary nature of the series. Gujarati (1999) shows that regression models involving time series data sometimes give results that are spurious, or of dubious value, in the sense that superficially the results look good but on further investigation they look suspect. This implies that the series might be non-stationary or contain unit root; a highly persistent time series process where the current value equals last period's value, plus a weakly dependent disturbance (Wooldridge, 2006). Noting Greene (2003), the Augmented Dickey–Fuller (ADF) test is employed to test for unit root.

Granger Causality

Provided that the agricultural, industrial, and service-related GDP are cointegrated, there is causality between the variables in at least one direction (Granger 1988). Furthermore, Engel and Granger (1987) proposed that the Granger causality for at least one direction could be tested as an error correction model. The model specification can be resulted as

$$\Delta y_{1t} = \delta_{1t} + \sum_{i=1}^{k} \alpha_{1i} \Delta y_{1t-i} + \sum_{i=1}^{k} \beta_{1i} \Delta y_{2t-i} + \delta_1 z_{t-1} + \varepsilon_{1t} \tag{11}$$

$$\Delta y_{2t} = \delta_{2t} + \sum_{i=1}^{k} \alpha_{2i} \Delta y_{2t-i} + \sum_{i=1}^{k} \beta_{2i} \Delta y_{1t-i} + \delta_2 z_{t-1} + \varepsilon_{2t} \tag{12}$$

where y_1 is the logarithm of agricultural GDP (*LAGDP*), y_2 is logarithm of industrial GDP (*LIGDP*), and z contains the cointegrating terms implied by the long-run nexus between *AGDP* and *IAGDP*. All coefficients in the first-differenced VAR terms can be tested for short-run causality. Finally, the dynamic behavior was estimated by error correction model and the long-run equilibrium was estimated. The same procedure was adopted with the agricultural GDP and service GDP to find the causation between the two sectors.

Cointegration with Structural Break and Vector Error Correction

The Gregory and Hansen (1996) residual-based test is employed for cointegration to test for structural break in the cointegrating relationship among the included variables. This approach is superior to the Engle and Granger (1987) approach to testing for cointegration, which tends to under-reject the null of no cointegration if there is a cointegration relationship that has changed at some (unknown) time during the sample period. The Gregory and Hansen test is an extension of the Engle and Granger approach and it involves analysis of the null hypothesis of no cointegration against a complementary of cointegration with a single regime shift in an unknown date based on extensions of the traditional ADF-, Za and Zt – test types.

The standard approach for cointegration (Engle and Granger 1986) has no structural change and has four independent variables and is based on the model given as

$$y_t = \mu + \alpha_1 x_t + \alpha_2 z_t + \alpha_3 e_{tt} + \alpha_4 s_t + \varepsilon_t \tag{13}$$

where x_t, z_t, e_t, s_t and the dependent variable y_t are I(1), the error term ε_t is I(0) and the μ, α_1 α_2 α_3 α_4 parameters are time invariant. However, it may be desirable to think of cointegration as holding over a fairly long period of time, and then shifting to a new long-run relationship. Thus, the timing of the shift is unknown but can be determined endogenously. The structural change will be reflected in changes in the intercept and/or changes in slopes. To model the structural change, Gregory and Hansen (1996) defined the indicator variable as follows:

$$\varphi_t = \begin{cases} o, & if \ t \leq [n\tau] \\ 1, & if \ t > [n\tau] \end{cases}$$

where the unknown parameter $\tau \in (0, 1)$ denotes the relative timing of the change point and $[n\tau]$ denotes integer part. To test for cointegration with structural breaks, they proposed some models, among which are level shift, level shift with trend, and intercept with slope shifts.

A. Level Shift (C) Model

$$y_t = \mu_1 + \mu_2 \varphi_t + \alpha_1 x_t + \alpha_2 z_t + \alpha_3 e_{tt} + \alpha_4 s_t + \varepsilon_t \tag{14}$$

This is a simple case in which there is a level shift in the cointegrating relationship, modeled as a change in the intercept μ, where the slope coefficients are held constant. This implies that the cointegration relationship has shifted in a parallel fashion. In this parameterization, μ_1 represents the intercept before the shift and μ_2 represents the intercept after the shift.

B. Level Shift with Trend (C/T) Model

$$y_t = \mu_1 + \mu_2 \varphi_t + \beta t + \alpha_1 x_t + \alpha_2 z_t + \alpha_3 e_{tt} + \alpha_4 s_t + \varepsilon_t \tag{15}$$

where β is the coefficient of the trend term, t.

C. Intercept and Slope Shifts (C/S) Model

$$y_t = \mu_1 + \mu_2 \varphi_t + \beta t + \alpha_1 x_t + \alpha_{11} \varphi_t x_t + \alpha_2 z_t + \alpha_{22} \varphi_t z_t + \alpha_3 e_{tt}$$
$$+ \alpha_{33} \varphi_t e_{tt} + \alpha_4 s_t + \alpha_{44} \varphi_t s_t + \varepsilon_t \tag{16}$$

$\alpha_1 \alpha_2 \alpha_3 \alpha_4$ denote the cointegrating slope coefficients before the regime shift and $\alpha_{11} \alpha_{22} \alpha_{33} \alpha_{44}$ denote the change in the slope coefficients.

In principle, the same approach used in equation (4) could be used for testing models (6) to (8) if the timing of the regime shift were known a priori. However, such breakpoints are unlikely to be known in practice without some appeal to the data. Within this framework, Gregory and Hansen (1996) proposed the test for cointegration with an unknown break date, which involves computing the usual statistics (ADF and PP test statistics) for all possible break points and then selecting the smallest values, since this will potentially present greater evidence against the null hypothesis of no cointegration. In this regard, the relevant statistics are the ADF (τ), $Z_a(\tau)$ and $Z_t(\tau)$.

A need for testing the long-term relationship is established in the model given the short-run disturbances. For this purpose, a dynamic error correction model, which can be used to forecast the short-run behavior of agricultural GDP growth, is estimated based on the cointegration relationship. Given that the lagged residual-error derived from the cointegrating vector is incorporated into a highly general error correction model, this leads to the specification of a general error correction model (ECM):

$$\Delta x_t = \pi_0 + \pi x_{t-1} + \pi_1 \Delta x_{t-1} + \pi_2 \Delta x_{t-2} + ... + \pi_p \Delta x_{t-p} + \varepsilon_t \tag{17}$$

After a cointegration test is established, a Vector Error Correction Model (VECM) can be estimated subsequently to determine the short-run dynamic behavior of agricultural, industrial, and service growth. The general-to-specific modeling approach was followed, first including two lags of the explanatory variable and of the error correction

(EC) term, and then gradually eliminates the insignificant variables in the approach (Banerjee et. al 1996).

6. EMPIRICAL RESULTS

This paper examines a long-term nexus among the agriculture, industry, and service sectors in Sri Lanka from 1950 to 2015. The empirical model specification follows a Unit root analysis, Granger causality test, G–H cointegration, and VECM. The results of the model were investigated through following analysis. The unit root analysis predicts the I(1) for all the variables, indicating that these variables can be cointegrated (Table 3).

Table 3: Unit Root Test Results

	Augmented Dickey–Fuller		Phillips–Perron	
	Levels	**First diff.**	**Levels**	**First diff.**
LAGDP	–4.56**	–3.18***	–3.53	–5.32***
LIGDP	–4.24	–2.74**	–5.61**	–7.94**
LSGDP	–3.50	–8.73**	–2.74	–6.38***

Table 4: Zivot and Andrews Unit Root Test

Variable				Critical Values	
(log)	**Break**	**t-Statistic**	**Break Year**	**1%***	**5%**
lnAGDP	Intercept	–7.713(1)***	1973	–5.43	–4.80
	Trend	–7.432(0)***	1985	–4.93	–4.42
	Both	–7.679(1)***	2003	–5.57	–5.08
lnIGDP	Intercept	–4.198(0)**	1981	–5.43	–4.80
	Trend	–4.981(1)***	1979	–4.93	–4.42
	Both	–5.950 (1)***	1978	–5.57	–5.08
lnSGDP	Intercept	–4.849(2)**	1967	–5.43	–4.80
	Trend	–4.921(1)**	1983	–4.93	–4.42
	Both	–5.802(1)***	1978	–5.57	–5.08

Notes: Number of lags in parenthesis is chosen as the highest significant lag out of a maximum of 4 lags. * denotes statistical significance at the 10% level, ** denotes statistical significance at the 5% level, and *** denotes statistical significance at the 1% level.

The presence of structural breaks in a time series leads the results of a unit root rest to be invalid. It also rejects the null hypothesis even when the series are nonstationary. Therefore, the results of unit root analysis presented above need to be tested by a third method—Zivot and Andrews test (Zandrews test)—which tests for unit root while considering the possibility of structural breaks. A single structural break for each of the series is identified from the results of the Zandrews test. Referring to Table 4, for the natural logarithm of AGDP, the break is in 2003 and the t-statistic of –7.679 is less than the critical value at the 1% level reading to the acceptance of the null hypothesis of nonstationarity; hence, the variable is nonstationary. For the natural log of IGDP, the break is in 1978 and the t-statistic of –5.950 is less than the critical value at the 1% level reading to the acceptance of the null hypothesis of nonstationarity. For the natural log of IGDP, the break is in 1978 and the t-statistic of –5.802 that is less than

the critical value at the 1% level leads to the acceptance of the null hypothesis. Hence, even when structural break is considered, all the three variables are nonstationary.

Vector Autoregression Estimations

VAR has been specified to identify the relationship between the sectoral GDPs and their lags. However, VAR is not stable in predicting the relationship of the sectoral interrelationships as the diagnostic and inference tests revealed. The suspicion is that there can be nonstationary series of GDPs, which affect the prediction. This leads to test for unit roots and adopt a cointegration analysis.

$$AGDP_t = 481.97 + 0.752 AGDP_{t-1} + 0.011 AGDP_{t-2} + 0.171 IGDP + 0.301 IGDP_{t-1}$$
$$(617.48) \quad (0.139)* \quad (0.154) \quad (0.745)* \quad (0.867)*$$
$$+0.215 SGDP - 0.411 SGDP_{t-1}$$
$$(0.656)* \quad (0.724)*$$

The results of the above model depicted the estimates of the VAR approach under the unstable condition. The post estimations of the VAR model were not stable in forecasting the relationship among the sectoral GDPs. Therefore, the series were tested against the stationary nature using ADF and PP tests of unit roots (Tables 3 and 4).

Table 5: Granger Causality Results

Regression Analysis	F-value
$\Delta \ln (AGDP) \, on \, \Delta \ln (SGDP)$	6.1296 (0.0123)***
[Null Hypothesis: AGDP does not Granger Cause SGDP]	
$\Delta \ln (SGDP) \, on \, \Delta \ln (AGDP)$	5.1867 (0.0030)***
[Null Hypothesis: SGDP does not Granger Cause AGDP]	
$\Delta \ln (AGDP) \, on \, \Delta \ln (IGDP)$	4.6967 (0.0452)***
[Null Hypothesis: AGDP does not Granger Cause IGDP]	
$\Delta \ln (IGDP) \, on \Delta \ln (AGDP)$	0.4678 (0.0549)
[Null Hypothesis: IGDP does not Granger Cause AGDP]	
$\Delta \ln (SGDP) \, on \, \Delta \ln (AGDP)$	1.7851 (0.0154)
[Null Hypothesis: SGDP does not Granger Cause IGDP]	
$\Delta \ln (IGDP) \, on \, \Delta \ln (AGDP)$	18.8534 (0.0865)**
[Null Hypothesis: IGDP does not Granger Cause SGDP]	

* denotes statistical significance at the 10% level, ** denotes statistical significance at the 5% level, and *** denotes statistical significance at the 1% level.

Sectoral Interdependencies

Unit root test based on ADF test confirms that the GDP series of the agriculture, industry, and service sectors are difference-stationary *I*(1) and integrated of order one. Structural change of the series of AGDP, IGDP, and SGDP shows the changes in different time periods from 1950 to 2015. At the outset, causality is checked between agricultural and industrial, agricultural and service-related GDPs with *I*(1) of the natural logarithms of each GDP series.

Subsequently, the causality between the sectors is estimated from 1950 to 2015 (Table 6). As Table 6 depicted, one-way causality between AGDP and the IGDP implies that the AGDP in Sri Lanka causes the industrial growth in economic growth. The pair-wise Granger causality test shows that there is only one-way causality from AGDP to IGDP, but not from IGDP to AGDP. However, the open economic scenario has been addressed with a dummy variable that is used for pre-open and post-open economic scenarios. The selection of the latter period is dictated by the fact that partial economic reforms in the service sector were set in during the early 1980s and speeded up during the 1990s. The results obtained from the estimation of equations indicate varying lag lengths in each case. As explained above, optimal lag lengths that minimize the Akaike's Final Prediction Error for testing equation are taken in the analysis. The direction of causality is explained along with the F statistics and their significance at the 5% level of significance in Table 5. Results showed that, in a bivariate pair-wise comparison, causality between agricultural growth and service growth is independent from 1950 to 2015, indicating a strong inter-linkage between the sectors in the growth process. Also, when the agriculture sector is linked with both industry and service, results display a statistically significant unidirectional linkage from agricultural to industry at lag 6.

Table 6: Interdependencies of the Sectoral Gross Domestic Product

Nexus between Inter-sector			Causality
AGDP	⟶	IGDP	Yes
AGDP	⟶	SGDP	Yes
IGDP	⟶	SGDP	Yes
IGDP	⟶	AGDP	No
SGDP	⟶	AGDP	Yes
SGDP	⟶	IGDP	No

This may be explained by a strong dominance of agriculture during the early years of development. Yet, the industrial-manufacturing sector, through increased demand for agricultural inputs such as seeds, fertilizers, machines, and pesticides being produced in the manufacturing sector, prop up the agricultural growth during early stage of the development.

Long-run Equilibrium

The long-run relationship of the agriculture sector and the other sectors in Sri Lanka has been identified using the cointegration analysis (Table 7).

As depicted in Table 7, the rate of growth of the sectors is represented in the following specification.

$$\Delta AGDP_t = -0.33 + 1.34 \Delta IGDP_t^{***} + 5.80 \Delta SGDP_t^{***}$$

Table 7: Gregory–Hansen Test for Cointegration with Regime Shifts

Type	Test Statistics	Date	Asymptotic Critical Values		
			1%	5%	10%
Level					
ADF	−8.22***	2000	−5.44	−4.92	−4.69
Zt	−8.29***	2000	−5.44	−4.92	−4.69
Za	−65.13***	2000	−57.01	−46.98	−42.49
Regime					
ADF	−4.77	1996	−5.97	−5.5	−5.23
Zt	−10.11***	1991	−5.97	−5.5	−5.23
Za	−77.79***	1991	−68.21	−58.33	−52.85
Regime and Trend					
ADF	−11.18***	1991	−6.45	−5.96	−5.72
Zt	−11.28***	1991	−6.45	−5.96	−5.72
Za	−82.88***	1991	−79.65	−68.43	−63.10

* denotes statistical significance at the 10% level, ** denotes statistical significance at the 5% level, and *** denotes statistical significance at the 1% level.

The cointegration analysis revealed that 1% increase in rate of growth in service sector increases 5.80% in agricultural growth rate. The results can be linked with the existing service sector growth in agricultural trade liberalization providing international market for agricultural goods and facilitating the business environment through credit and service-related economic activities. This implies that the increase in service-related agricultural systems could prop up the agricultural growth in the economy. However, in line with the above results, a 1% increase in industrial growth also increases the agricultural growth by 1.34% in Sri Lanka. The basic reason for the agriculture sector's decline is due to the labor movement from agriculture to the industry and service sectors. In 1963, the sectoral labor forces were 52.6% in the agriculture sector, 9.1% in the industry sector, and 32% in the service sector. In 2000, agricultural labor force declined to 34%, while industrial labor force increased to 17% and service sector labor force increased to 41%. However, bidirectional causality and a positive relationship between agricultural and service growth provide the direction that service growth is favorable for agricultural growth, which has mutual benefits and interdependency in the economy.

Short-term Dynamics

The dynamic nature of the sectoral growth can be captured in the error correction model. As the VECM is predicted, the following specification can be derived from Table 8.

$$\Delta AGDP_t = -0.001 + 0.515 AGDP_{t-1}^{***} - 0.882 \Delta AGDP_t^{***} - 0.464 \Delta IGDP_t - 2.107 \Delta SGDP_t^{***}$$

$$\Delta IGDP_t = -0.003 - 0.073 IGDP_{t-1} + 0.162 \Delta AGDP_t - 0.307 \Delta IGDP_t + 0.673 \Delta SGDP_t$$

$$\Delta SGDP_t = -0.002 - 0.073 SGDP_{t-1}^{***} + 0.179 \Delta AGDP_t + 0.203 \Delta IGDP_t^{***} + 0.573 \Delta SGDP_t^{***}$$

Table 8: Vector Error Correction Results

		Coefficients	SE	P>|z|
AGDP				
	Ce_I L1	0.515***	0.110	0.000
	AGDP LD2	−0.882***	0.241	0.000
	IGDP LD2	−0.464	0.225	0.069
	SGDP LD2	−2.107***	0.552	0.000
	Cons	0.001	0.011	0.967
IGDP				
	Ce_I L1	−0.073	0.075	0.334
	AGDP LD2	0.162	0.165	0.329
	IGDP LD2	−0.307	0.175	0.080
	SGDP LD2	0.673	0.379	0.067
	Cons	0.003	0.007	0.687
SGDP				
	Ce_I L1	−0.319***	0.047	0.000
	AGDP LD2	0.179**	0.103	0.046
	IGDP LD2	0.203	0.109	0.085
	SGDP LD2	0.573**	0.237	0.016
	Cons	−0.002	0.004	0.763
Adjusted R^2		0.43		
Log Likelihood		313.737		
Akaike Information Criteria (AIC)		−10.059		
HQIC		−9.825		
Schwarz Criteria (SBIC)		−9.460		
Sample (adjusted):		1953–2011		
Included Observations:		59		

The results depicted that the underline rate of growth of agriculture is estimated as 1.6% per year. This implies that the rate of change in agricultural growth at present is very slow in the country. As cointegration predicted the long-run behavior of the sectoral growth, the short-run semi-elasticities are –0.26, and +0.42, implying that a 1% increase in industrial growth rate retards agricultural growth by 0.26%, while a 1% increase in service growth increases agricultural growth by 0.42%.

7. CONCLUSIONS AND POLICY IMPLICATION

The growth empirics provide the direction to policy implications through the quantitative approach of sectoral interdependencies for the revitalization of the sectoral growth. In Sri Lanka, agriculture sector growth depends highly on service sector growth but not on industry sector growth. Both the industry and service sectors are interdependent on agriculture sector growth, performing as a driving factor of the economics growth of the country. Thus, the policy impact to increase agricultural growth is minimal in Sri Lanka, even after open economics scenario, or at different policy adjustments. The analysis provided the pragmatic evidence on the requirement to promote service sector-related agricultural systems, with the existing capacity of production to promote agriculture sector involvement and thereby growth. However, the liberalization of agricultural

market promoting exportation and facilitating agricultural services enhance the economic growth of the country.

It appears from the analyses that Sri Lanka's economy has undergone a structural shift, particularly from the early 1980s when Sri Lanka embarked upon structural adjustment program. A higher rate of growth is observed in the service and industry sectors compared with that in the agriculture sector (Figure 1). Inter-sectoral relationships investigated using Granger causality test from 1950 to 2007 verify the theoretically recognized causal relationship between agriculture and industry as unidirectional and agriculture and service as bidirectional interdependencies. Empirical results, further, support that two-way linkage between the agriculture and service sectors provide evidence for economic reforms in reviving agriculture–service relationships. Nonetheless, strong evidence of a long-run positive relationship between agricultural growth and service growth provides the fact that policy reforms related to agricultural service sector promotions are beneficial to agricultural growth in the country.

The study can be related to numerous policy directions, including mainly constructing national agricultural policy framework, promoting service sector-related agricultural production systems, investing on public agricultural research, extension services, modernized technology policies, stabilizing tariff policies, policy reforms in land administration, water, labor, commodity market, promoting commercial private sector, and export market facilitation.

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APPENDIX

Vector Autoregression Post-Estimation Tests

Table A.1: Eigenvalue Stability Condition

Eigenvalue	Modulus
0.4964 + 0.8792i	1.0097
0.4964 − 0.8792i	1.0097
0.9508	0.9508
0.8087 − 0.1689i	0.8262
0.8895	0.8262
−0.2048	0.2048
0.0481	0.0481

Note: At least one eigenvalue is at least 1.0.

VAR does not Satisfy Stability Condition.

Table A.2: Selection Order Criteria

Lag	LL	LR	P	AIC	HQIC	SBIC
0	−2,012.60			72.0213	72.0774	72.1659
1	−1,667.76	689.68	0.00	60.2770	60.5574	61.0003
2	−1,624.49	86.534*	0.00	59.3032*	59.8080*	60.6052*

Note: Endogenous; agdp igdp sgdp.

Table A.3: Normality; Jarque-Bera Test, Skewness Test, Kurtosis Test

Equ	Jarque-Bera Chi^2	p Value	Skewness	P Value	Kurtosis	P Value
AGDP	103.24	0.00	1.015	0.00	9.334	0.00
IGDP	120.57	0.00	1.202	0.00	9.775	0.00
SGDP	31.50	0.00	−0.473	0.14	6.551	0.00
All		0.00		0.00		0.00

Structural Break of the Series with Zivot-Andrews Test

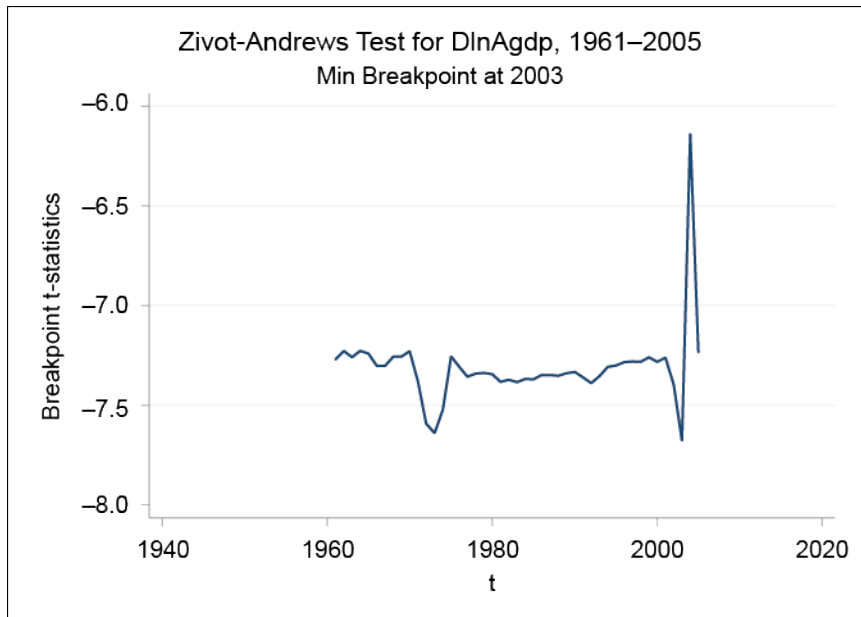**Figure A.1: Structural Break of Agricultural GDP**
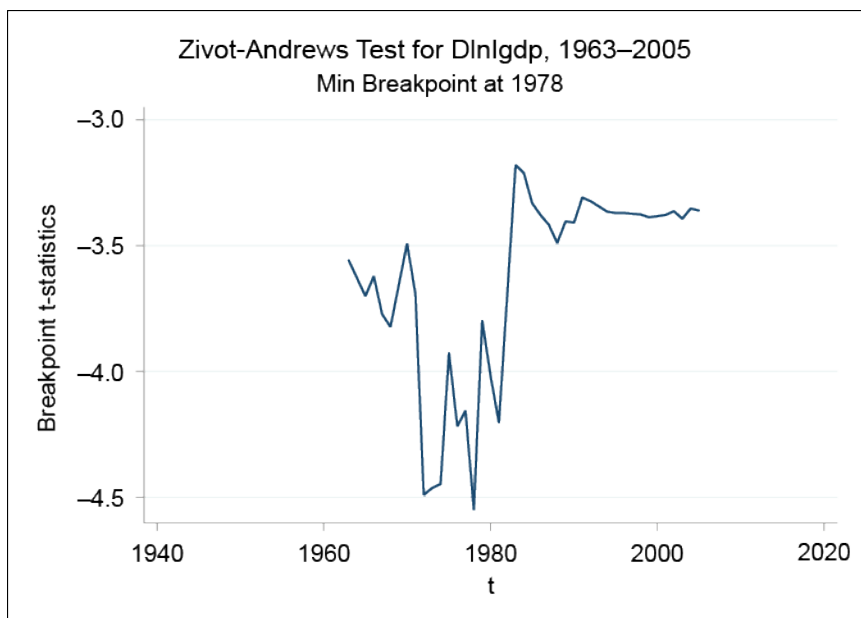

Figure A.2: Structural Break of Industrial GDP

Figure A.3: Structural Break of Service GDP