SECTORAL OUTPUT, GROWTH AND ECONOMIC LINKAGES IN THE BARBADOS ECONOMY OVER THE PAST FIVE DECADES
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DOWNES, Darrin
GREENIDGE, Kevin
STEADMAN, Keva

Abstract
Using multivariate cointegration analysis, this paper investigates the long run and short-run relationships between the agriculture, industry and service sectors for Barbados over the past five decades. Sectoral real output is analysed in two sub-periods: 1946 to 1969 and the years 1970-2003. The reason for splitting the sample is to investigate whether the commonly held view that a structural transformation from an economy dominated by agriculture to one that is predominantly service-oriented was reflected in the data. One cointegrating relationship is found in both sub-periods. The results suggest that for the earlier period, increases in industrial output (services output) were associated with lower (higher) agricultural GDP over the long run. In the short run, only changes in industrial output promoted growth in agricultural output. In the latter period, an expansion in services output was found to be the only determinant of industrial output in both the short and long run, as agricultural output did not appear to have any statistically significant impact in either timeframe.

JEL Classification: O0, O1, C3
Key words: Economic linkages, Structural change, Growth, Sectoral output

1. Introduction

Barbados is on the threshold of probably the most uncertain, yet optimistic, period of its economic history. Indeed, notwithstanding the many structural rigidities and other singular challenges within CARICOM, Barbados is on the verge of entering into a historic single market arrangement with Trinidad and Tobago and Jamaica, preparing for the eventual participation in a Free Trade Area of the Americas and for a new economic partnership agreement in Europe by 2007, as well as engaged in ongoing negotiations in the World Trade Organisation. These processes are exerting considerable burdens on the human, administrative and financial resources of the national authorities and involve some rethinking of past development strategies.

The ultimate aim of the restructuring process required, which is necessary for the effective participation in a more liberalised economic environment, must be to quickly refocus and implement viable policies primarily capable of boosting export competitiveness. An important step towards the achievement of this objective is an understanding of not only the evolution of real output across economic sectors, but also

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1 CARICOM refers to the countries of the Caribbean Community. The members are Jamaica, Trinidad and Tobago, Barbados, The Bahamas, St Lucia, St Vincent and the Grenadines, St Kitts and Nevis, Grenada, Montserrat, Dominica, Antigua and Barbuda, Haiti, Suriname and Guyana.
the size and direction of their interactions over time. In so doing, government policies can be better crafted and resources optimally directed, thereby placing the economy in a better position to avoid or, hopefully, even lessen the possibility of boosting unproductive sectors.

Following the seminal work of Lewis (1954) and Hirschman (1958), early development theorists have focussed on modelling the development process in terms of a structural transformation from agriculture to industrial activities, predicated on the view that the agricultural sector provides important inputs, such as labour, raw materials and financial savings to assist in industrial development. In some cases, these sectors may be complimentary, with both forward and backward linkages, primarily between the agricultural and manufacturing sectors. More recently, however, some authors have acknowledged the prominent role of services in the development process [see Blunch and Verner (1999) and Gemmell, Lloyd and Mathew (1998)]. In the case of Barbados, services output has emerged as the dominant economic sector since the 1970s, accounting for roughly three quarters of total real output and seventy percent of total foreign exchange earnings as at the end of 2003.

Against this background, this paper investigates the nature of the intersectoral linkages among the agricultural (sugar agriculture and non-sugar agriculture and fishing), industrial (manufacturing, mining and quarrying, public utilities and construction), and the services sectors (tourism, wholesale and retail trade, financial, business, government and general services) in Barbados over the past fifty years. An empirical examination of these linkages can shed light on whether, for example, output changes in a particular sector is likely to be associated with either higher or lower output in other sectors both in the long run and short run, or more appropriately, whether the direction of causation between the aggregated sectors is unidirectional or there is feedback. In short, policy makers can better understand the sector(s) that principally drives economic growth. Another important question this study seeks to answer is the speed at which the sectors adjust in the long run after experiencing economic shocks.

These intersectoral linkages are estimated using multivariate cointegration techniques, an approach well suited to this type of investigation. Indeed, the significance of investigating the interrelationships among the sectors over the long and short run is predicated on the belief that the accumulation and allocation of the factors of production, particularly technological progress, which all underlie sectoral output interactions, is expected to vary over time. The empirical analysis is done for two sub-samples: 1946 to 1969 and 1970 to 2003. The reason for splitting the sample period in the manner described is to ascertain whether the results reflect the structural transformation in the Barbados economy from an agrarian economy to a service-oriented one during the post-independence period. An important caveat is that this study is mainly concerned with the statistical description of the linkages among the aggregated economic sectors mentioned above, and does not seek to provide an explanation of their interaction or outline a model of their development over the period analysed. The authors will, hopefully, some time in the future undertake a comprehensive survey of these sectors to quantify these hypothesised linkages. Also, given the relevance to policy the linkages for the latter period are explored in greater detail.

After the introduction, section two chronicles the evolution of the economic sectors since the late 1940s; section three describes the econometric methodology, data
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sources and description of the variables used in the empirical analysis; section four presents the empirical results; section five concludes with a few policy implications.

2. The Growth and Changes in Sectoral Contributions to Domestic Output

Over the past fifty years, the structure of the Barbados economy has undergone considerable change from one largely dependent on primary agriculture, more specifically sugar agriculture, to an economy that is predominantly service-oriented, with tourism and, more recently, international business and financial services being the main sources of foreign exchange earnings. Indeed, the decline in the output share of the agricultural and fishing sector started from the mid-1950s and gained momentum in the late 1960s [Figure 1]. By yearend 2003, real output from agricultural and fishing activities (as a percentage of total real GDP) had fallen to less than one-fifth of its contribution at the beginning of the sample period. In marked contrast, the contribution of the aggregate services sector to total real output rose sharply from a share of around 60 percent of domestic output in the mid 1940s to three-quarters by the end of the period under analysis [Table 1].

**Table 1. Sectoral Shares of Total Real Gross Domestic Product: 1946-2003**

<table>
<thead>
<tr>
<th>Sub-period</th>
<th>Total Agriculture</th>
<th>Sugar Agriculture</th>
<th>Non-Sugar Agriculture</th>
<th>Industry</th>
<th>Manufacturing</th>
<th>Tourism</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>1946-60</td>
<td>0.323</td>
<td>0.256</td>
<td>0.067</td>
<td>0.080</td>
<td>0.020</td>
<td>0.048</td>
<td>0.596</td>
</tr>
<tr>
<td>1961-70</td>
<td>0.185</td>
<td>0.149</td>
<td>0.036</td>
<td>0.104</td>
<td>0.050</td>
<td>0.110</td>
<td>0.711</td>
</tr>
<tr>
<td>1971-80</td>
<td>0.085</td>
<td>0.057</td>
<td>0.029</td>
<td>0.160</td>
<td>0.087</td>
<td>0.214</td>
<td>0.755</td>
</tr>
<tr>
<td>1981-90</td>
<td>0.074</td>
<td>0.040</td>
<td>0.034</td>
<td>0.177</td>
<td>0.093</td>
<td>0.242</td>
<td>0.749</td>
</tr>
<tr>
<td>1991-03</td>
<td>0.062</td>
<td>0.024</td>
<td>0.038</td>
<td>0.195</td>
<td>0.092</td>
<td>0.152</td>
<td>0.743</td>
</tr>
</tbody>
</table>

Source: Central Bank of Barbados data files

**Figure 1. Evolution of Sectoral Output Shares: 1946-2003**
Between 1946 and 1960, agriculture accounted for an output share of just over one-third of total real GDP and jobs for roughly two-thirds of the working population. In particular, sugar production contributed one-quarter of domestic output and exports receipts of over two-thirds of total earnings from merchandise exports [Worrell, 1982]. During this period, sugar agriculture was profitable for plantation owners, as the Commonwealth Sugar Agreement, which was initiated in 1951 to provide a guarantee market for Barbados’ sugar exports to the U.K. at preferential prices, stabilised the foreign exchange earnings of the industry.

It was not until the late 1960s that the relative economic importance of agriculture, in particular sugar production, in overall economic activity started to show signs of decline. The view at the time was that the dependence on the production of bulk sugar increased the vulnerability of the domestic economy to unanticipated shocks in both the output and the export price of sugar. The Governments of Barbados, therefore, embarked on a programme of export diversification, shifting focus towards other areas capable of generating sustained net foreign exchange inflows. In this regard, tourism and light manufacturing offered viable alternative avenues for the creation and maintenance of employment, government revenue and foreign exchange earnings [Cox, 1982].

In spite of the declining relative contribution of agriculture to overall domestic economic activity, the sector is still recognised as important in the cultural and economic life in Barbados. In fact, the largest cultural festival, Crop Over, in Barbados is a celebration of the end of harvesting the sugar cane crop. Furthermore, the agricultural sector has both forward and backward linkages, however limited, with both the industrial and services sectors. For instance, output from agriculture provides raw materials, such as fruits, vegetables, poultry, and livestock, for the manufacture of processed foods, (sugar cane) molasses for the manufacture of rum, as well as (sea island) cotton for the garment and textile industry. The agriculture sector also complements certain categories of services activity via links with tourism and the wholesale and retail trade (distribution). The relationship has sparked considerable debate for some time, as local farmers have lamented the fact that tourism establishments import the bulk of food to satisfy the industry needs.

Notwithstanding these benefits, however, output growth in agriculture could be negatively affected by the diversion of foreign and domestic investment to other (competing) sectors, as well as by the influx of imported substitutes, particularly those goods that are produced locally for consumption and production purposes. In addition, for instance, with the continued development of the industrial and services sectors, more job opportunities could very well become available with a less menial attachment, resulting in the movement of persons out of agriculture into these sectors. In the last decade, the declining profitability of the sugar industry has prompted some producers to subdivide sugar lands for the lucrative housing and real estate market.

In the post-independence period, while the economic contribution of the agricultural and fishing sector continued on a downward trend, these years heralded the further growth of the services sector, with tourism making the most remarkable

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2 In the case of Barbados, there has been a steady decline in the number of locals working in the agriculture industry. As a result, migrant workers from neighboring islands have had to pick-up the slack.
improvement of all sub-sectors. In the period 1971-80, the average share of sugar agriculture had fallen to around 6%, compared to an average share of approximately 15% in the previous decade, while total agriculture accounted for just about one-tenth of total real GDP. In contrast, the sectoral output shares of the services and industrial sectors, fuelled by significant growth in tourism output in the case of the former and manufacturing for the latter.

Over the next twenty years, the structural transformation of the Barbados economy was more evident, with the agricultural sector, most noticeably sugar production, losing further ground, and more prominence being accorded to services activity. In fact, while the output share of industrial activity remained relatively stable, aggregated services GDP expanded further to almost three-quarters of total domestic output. Despite the precipitous decline in agricultural GDP, the Government of Barbados has continued to support agricultural activity, providing various incentives for the production of crops such as cotton and the rearing of livestock. In addition, the sugar industry is being transformed into a sugar cane industry. Rather than concentrate on the sale of bulk sugar, as done in the past, the focus is now geared towards the production of value-added products from the sugar cane plant and its by-products. Moreover, local farmers are being encouraged to adopt more technologically advance techniques, such as the growing of vegetables in greenhouses and the use of hydroponics to boost production.

3. Data and Econometric Methodology

The data used in this study are annual observations spanning the sample period 1946 to 2003. The sectoral real GDP data (1974 prices) were collected from the Central Bank of Barbados data files. The variables were converted into their logarithms, with agricultural output denoted as $\text{lagri}$, industrial output by $\text{lin}$ and aggregate services output by $\text{lserv}$. The empirical analysis was conducted within Eviews Version 5.0.

An inspection of the plots of each raw data series in levels revealed trending, nonstationary variables. Thus, before proceeding with the estimation, each series was tested for unit roots, using the Augmented Dickey-Fuller (ADF), Phillips-Perron and Kwiatkowski et al (KPSS) tests. In the case of the ADF test, the equations for each level series were estimated first with only an intercept term, and then both with intercept and trend terms. For the differenced series, only an intercept was necessary, since the trends in each series were removed. In addition, the appropriate number of lagged first differenced terms of the dependent variable, which were needed to correct for higher-order serial correlation of the errors in the ADF test equation, were included. These unit root tests are important because, according to the Granger representation theorem, if the variables under study are integrated of the same order, i.e., greater than zero, then there might exist a linear combination of them that is stationary. Indeed, given the hypothesised interdependences of the economic sectors, there should exist some long-run relationship among the variables of interest.

Following the tests for the order of integration of each data series, the Johansen (1988) procedure was used to determine whether the variables were cointegrated. Unlike the Engle-Granger (1987) two-step approach, which assumes a unique economic endogenous relationship, the Johansen approach estimates the maximum number of
cointegrating relationships (vectors) among economic variables, using Vector Autoregression (VAR) methodology, when there is little or no a priori knowledge of their association. Therefore, the modeling approach involves a multivariate VAR that includes the three (aggregated) sectoral output variables lagri, lind and lserv.

Consider the following general VAR (k) model

$$Z_t = \mu + \sum_{i=1}^{k} A_i Z_{t-i} + \epsilon_t,$$

where $Z_t$ is a (nx1) column vector comprising the current values of the endogenous variables, $\mu$ is a (nx1) column vector of deterministic components, $A_i$ (nxn) matrices of non-zero coefficients, and $\epsilon_t$, a nx1 column vector of identically and independently distributed random errors. From this VAR, the basic equation of the Johansen procedure can be derived by applying a “cointegrating transformation” and can be expressed as:

$$\Delta Z_t = \mu + \Pi Z_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta Z_{t-1} + \xi_t,$$

The $\Pi$ matrix represents the constant dynamic adjustment of the lagged first differences of the variables on their levels, i.e., their long-run (cointegrating) relationship, whereas the $\Gamma$ matrix captures their short-run adjustment. In particular, the $\Pi$ matrix encapsulates the intertemporal sectoral linkages formed during the process of economic development. The significance of the Granger representation theorem is determined by the rank of the coefficient matrix $\Pi$. This is because if the $\Pi$ matrix has a reduced rank, i.e., greater than zero, but less than three cointegrating equations, then an error correction representation of the variables can be formulated and Granger causality is implied in at least one direction.

Formally, the $\Pi$ matrix can be decomposed into two matrices as:

$$\Pi = \alpha \beta,$$

where $\alpha \beta$ represents the matrix of adjustment coefficients with both $\alpha$ and $\beta$ being n x r matrices of rank r $\leq$ n. The $\alpha$ matrix contains the weighting elements or error correction coefficients and the $\beta$ matrix the long-run or cointegrating vectors. With respect to the rank of the $\Pi$ (3x3) matrix, three scenarios can be postulated:

1. $\Pi$ has full rank and the variables are stationary. Therefore, a VAR in levels can be estimated.
2. $\Pi$ has rank of 0 $< r < 3$, and there are r cointegrating vectors among the variables. In this case, a vector error correction (VEC) is estimated. In other words, a reduced rank indicates that there are r I(0) linear combinations of the n I(1) variables in the cointegrating system.
3. $\Pi$ has zero rank and there are no cointegrating vectors. The variables are stationary in first differences and an unrestricted VAR can be estimated without loss of relevant information.

The trace and maximum eigenvalue test statistics were used to check for the rank of the $\Pi$ matrix. These tests involve sequentially testing the null hypotheses of no cointegrating equations to n-1 cointegrating equations all against the alternative of full rank until the null can no longer be rejected. Again, these tests are standard and merit no further
explanation. The minimum Schwarz Bayesian Criterion (SC) determined the optimum lag length to be included in the VAR.

4. Empirical Results

As depicted in Figure 1, the share of agricultural GDP steadily declined over the sample period, most noticeably after 1970, while there was accompanying growth in the share of services GDP, suggesting some structural transformation mainly from an agricultural-based to services-based economy over the past three decades. In support of this supposition, Figure 2 provides the results of a unit root test for structural break around the year 1970. To investigate which sector(s) caused (forced) changes in the other sectors before and after this hypothesised change in the economic structure, the sample (1946-2003) was split into two sub-samples: (1946-69) and (1970-2003), and cointegration techniques were conducted for each sub-sample.

Sub-Sample 1: 1946-1969

An examination of the autocorrelation plots of the (three) variables to be included in the VAR, first in levels and then in first difference form, along with the results of the unit root tests indicate that the variables are integrated of order one. The next step involved the determination of a data consistent VAR, by systematic checks to confirm the presence of normality and no serial correlated or heteroskedasticity residuals of the chosen VAR model. A misspecified test was also carried out. Having verified a data consistent VAR specification, we proceeded to check for the number of cointegrating vectors among the variables. Both the trace and maximum eigenvalue tests indicate the presence of a single cointegrating vector at the 0.10 significance level [Table 2].

<table>
<thead>
<tr>
<th>No. of Cointegrating Vectors</th>
<th>Eigenvalue</th>
<th>Maximal Eigenvalue</th>
<th>Trace Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Null r=0</td>
<td>r=1</td>
<td>0.80461</td>
<td>34.288**</td>
</tr>
<tr>
<td>Null r=0</td>
<td>r=2</td>
<td>0.24885</td>
<td>6.009</td>
</tr>
<tr>
<td>Null r=0</td>
<td>r=3</td>
<td>0.10143</td>
<td>2.246</td>
</tr>
</tbody>
</table>

Note: r represents the number of cointegrating vectors. * and ** denote statistically significant values at the 5% and 10% level, respectively.

In testing for the structural break the procedure in Saikkonen and Lütkepohl (2002) and Lanne et al. (2002) is followed, where a shift function is added to the standard DF regression and the deterministic term is then first estimated by a generalised least squares (GLS) under the unit root null hypothesis and subtracted from the original series. Then an ADF type test is carried out on the adjusted series, which also includes terms to correct for estimation errors in the parameters of the deterministic part. The critical values for the new ADF statistic are given in Lanne et al. (2002). Saikkonen and Lütkepohl (1999 and 2002) provide details on the specification of the various shift function.

The autocorrelation plots and the results of the unit root tests can be made available from the authors upon request.
Variable exclusion tests confirmed that the individual variables (sectoral GDPs) do belong to the long-run model. In order to derive the long-run estimates, we begin by imposing an exact identification in sequential order. Since there is only one cointegrating vector this entails first setting the coefficient of $lagri$ to one, then checking the significance of the error correction-term in the three short-run equations, then repeating the process with the coefficient of $lind$ equal to one, then $lserv$. This analysis indicates that when normalisation on $lagri$ is done, the error-correcting term is significant in the short-run equations for $lagri$ and $lserv$. With the normalisation on $lind$, the error-correcting term is insignificant in all three short-run equations, while normalising on $lserv$ produces an exploding system. Hence, the analysis proceeded by normalising on $lagri$. Note that $lind$ is weakly exogenous in the cointegrating system, while both $lagri$ and $lserv$ respond to disequilibrium. Therefore, the long-run equilibrium relationship among the sectoral GDPs is of the form:

$$lagri = 8.453.668lind + 4.243lserv$$  (4)

The long-run relationship appears to be quite stable and well defined. In fact, Figure 2 shows the time profile of system-wide shocks to the long-run relationship and indicates a rapid convergence to equilibrium. Moreover, the effects of shocks to the individual variables (variable-specific as opposed to the previous system-wide shocks) on the cointegration relation (shown in Figure 3A) die out.

The equation implies that changes in industrial and services output result in opposite impacts on agricultural output in the early stages of Barbados’ economic development. In other words, agricultural output does not Granger-cause output in either the industrial and services sectors. In effect, a 1 percent increase in industrial GDP retards agricultural GDP by 3.7 percent, while a similar rise in services GDP leads to an increase of 4.2 percent in agricultural GDP, thus offsetting the estimated “harmful impact” of the industrial sector.

During this period, although the industrial sector, which mainly involved manufacturing, was at an infant stage, there could have well been a stronger competition for factor inputs, particularly labour between the agricultural and industrial sector than in the services sector. The estimated coefficients, although quite large, are plausible, since shocks to the domestic economy in the 1950s and 1960s required fairly sizeable changes in the agricultural sector to restore internal balance.

The general-to-specific approach popularised by Hendry et al (1993) was used to determine parsimonious dynamic models, which captures the short-run movements governing the long-run relationship. Starting with an over parameterised model, with two lags because of data constraints, the systematic reduction in the initial model produced the results in Table 3.

Note that since there are three variables in the VAR there are also three equations governing the short-run dynamics of the system. In practice, the findings of weak exogeneity allow the researcher to proceed only with the estimation of the short-run equation in which the error-correction term is significant without loss of any significant
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information. However, given the focus of the study, all the short-run equations are estimated, since they still can convey information about linkages between the variables. The results of the diagnostic tests indicate that in each case the model is adequately specified, as the residuals do not violate the classical statistical assumptions of normality, serial independence and homoskedasticity.

### Table 3. Short-run Dynamics: Adjusted Sample (1946-1969)

<table>
<thead>
<tr>
<th>Dependent Variable:</th>
<th>dlin</th>
<th>dlagri</th>
<th>dlserv</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.1235 (4.6948)</td>
<td>-1.6540 (2.4189)</td>
<td>1.2949 (5.7474)</td>
</tr>
<tr>
<td>dlserv(_t-1)</td>
<td>-0.4347 (-1.9452)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dlagri(_t-2)</td>
<td>-0.5101 (-2.1508)</td>
<td></td>
<td>-0.2173 (2.9102)</td>
</tr>
<tr>
<td>dln(_t-1)</td>
<td>-0.4844 (-3.1421)</td>
<td>1.0931 (2.4655)</td>
<td>-0.3021 (-2.5198)</td>
</tr>
<tr>
<td>dln(_t-2)</td>
<td></td>
<td>0.5839 (1.9894)</td>
<td></td>
</tr>
<tr>
<td>ect(_t-1)</td>
<td>-0.2885 (-2.3552)</td>
<td>0.2297 (5.6326)</td>
<td></td>
</tr>
</tbody>
</table>

**Diagnostic Tests (p-values)**

<table>
<thead>
<tr>
<th></th>
<th>Adjusted R(^2)</th>
<th>DW</th>
<th>Ramsey Reset Test: F-statistic</th>
<th>Normality:</th>
<th>BG Serial Correlation: F-statistic</th>
<th>ARCH Test: F-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.36</td>
<td>1.84</td>
<td>0.0013(0.971)</td>
<td>0.756(0.686)</td>
<td>0.1393(0.709)</td>
<td>0.0639(0.800)</td>
</tr>
<tr>
<td></td>
<td>0.30</td>
<td>1.88</td>
<td>3.011(0.156)</td>
<td>1.1444(0.486)</td>
<td>0.0727(0.787)</td>
<td>0.1028(0.748)</td>
</tr>
<tr>
<td></td>
<td>0.75</td>
<td>1.59</td>
<td>0.0176(0.895)</td>
<td>0.6578(0.720)</td>
<td>0.9995(0.317)</td>
<td>0.4566(0.499)</td>
</tr>
</tbody>
</table>

Note: Unless otherwise mentioned, figures in parentheses are t-statistics.

The results confirm the earlier analysis that both lagri and lserv respond to the disequilibrium term with negative and positive signs respectively. Hence, an increase in the combined output of services and industry (hence services output growing faster than industry) in the previous period (relative to agriculture output) will bring lagri, lind and lserv below the stationary combination (hence a negative deviation term\(^5\)), which in turn will either increase agriculture output or reduce service output or a combination of both to restore equilibrium. In addition to the linkage via the error-correcting term, there are also direct links through lagged terms. In the case of agriculture output, it appears that only past changes in industrial activity impact on agricultural output in the short-run.

The estimated coefficients, which can be interpreted as growth rates and suggest that a one percentage point increase in industry GDP has a significant two-year impact on agricultural output, raising it in the first year by roughly 1 percent and then by approximately 0.6 percentage points. However, taken with the long-run estimates this

\[ \Delta lagri_t = \beta_0 - \alpha \left[ lagri_{t-1} - (8.45 - 3.67 lind_{t-4} + 4.24 lserv_{t-4}) \right] + \Delta X_{t-1}. \]

Hence, a negative error-correction term exists if the term in the squared-brackets is negative. A similar equation exist for lserv.

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\(^5\) The error-correction model for lagri can be written as:

\[ \Delta lagri_t = \beta_0 - \alpha \left[ lagri_{t-1} - (8.45 - 3.67 lind_{t-4} + 4.24 lserv_{t-4}) \right] + \Delta X_{t-1}. \]
would imply that eventually agriculture output will contract below its original level. The results for services suggest that short-run changes in both agriculture and industry outputs have a negative impact on the growth of services output. A similar picture exists in the case of changes in industry output. Overall, the results suggest that the sectors have generally expanded at the expense of each other during this period, perhaps by drawing resources away from each other; more so between industry and services.

Sub-Sample 2: 1970-2003
In the analysis of this data set, the unrestricted VAR indicated some non-normality in the residuals around the years 1982 and 1992, which coincided with downturns in the domestic economy. In particular, the recession in the early 1990s was the most severe, with the brunt of the fallout occurring in the foreign exchange earning sectors. A check of the data confirmed that real output declined by some 5 percent in 1982 and 7.2 percent in 1992. Therefore, to achieve a data consistent VAR specification, (pulse) dummy variables were included in the VAR and treated as exogenous I(0) variables to account for these shocks.

Again, both the trace and maximum eigenvalue tests indicated the presence of one long-run cointegration equation (see Table 4) among the sectoral output variables at the 10 percent significance level.

<table>
<thead>
<tr>
<th>Table 4. Cointegration Rank Tests in the 1970-2003 Sub-Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>(33 observations after adjustments)</td>
</tr>
<tr>
<td>No. of Cointegrating Vectors</td>
</tr>
<tr>
<td>-------------------------------</td>
</tr>
<tr>
<td>Null</td>
</tr>
<tr>
<td>r&lt;=1</td>
</tr>
<tr>
<td>r&lt;=2</td>
</tr>
</tbody>
</table>

Note: r represents the number of cointegrating vectors. * and ** denote statistically significant values at the 5% and 10% level, respectively.

The variable exclusion tests indicate that lagri does not belong to the cointegrating space. Hence, the model is estimated by imposing the over-identifying restriction that the coefficient on lagri is zero. The resulting log-likelihood ratio statistic suggests that the restriction is valid. The long-run equilibrium relationship is expressed as:

\[ lind = -0.0771 + 0.7671lserv \]  

(5)

Thus, a 1 percent increase in services output raises industrial output by around 0.8 percent, while changes in agricultural output do not seem to have any long-run impact on the outcome in other sectors or vice versa. In other words, the agricultural sector in the post-1970 era appears not to have any significant long-run linkages with industry and services. To examine the effect of system-wide shocks on the long-run relation the persistence profile for the cointegrating vector is plotted in Figure 2. The figure indicates a strong tendency to converge to equilibrium following a system-wide shock. In fact, by the third period, most of the effect of the shock has dissipated. The effects of variable
specific shocks on the cointegrating vector are shown in Figure 3B and in each case the effect of the shock dies out.

With regard to the short-run dynamics, both agriculture and services output were found to be weakly exogenous, with industrial output being the variable that responds to disequilibrium in the system. Nevertheless, as before the three dynamic equations are estimated. Table 6 presents the short-run system, which depicts the dynamics for each output equation. In the equation describing the dynamics of industry output, the error-correction term indicates a speed of adjustment (37 percent each period) to the long-run equilibrium. Therefore, a shock to the system would take just under three years to dissipate. All in all, it implies that changes in services drive the system with industrial output responding greatest to deviations from steady-state (long-run) equilibrium. In addition to responding to disequilibrium, changes in industry output is influenced by lagged changes in the growth rate of services output with elasticity of 0.6, which is somewhat lower than the long-run impact. The other dynamics of the system indicate that past changes in services along with changes in industry output impact on current changes in services output, while movements in agriculture output in the short-term is dependent solely on its growth rate two periods earlier. Hence, services output seems to be the main driver, both in the short- and long-run.

<table>
<thead>
<tr>
<th>Dependent Variable:</th>
<th>dlind</th>
<th>dlagri</th>
<th>dlserv</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.0445(4.18)</td>
<td>-0.0246(2.46)</td>
<td>0.0149(2.85)</td>
</tr>
<tr>
<td>dlserv_{t-1}</td>
<td>0.5467(2.01)</td>
<td>-0.3433(2.01)</td>
<td></td>
</tr>
<tr>
<td>dlagri_{t-2}</td>
<td>-0.3433(2.01)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dlind_{t-2}</td>
<td>-0.1387(-2.04)</td>
<td></td>
<td></td>
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<tr>
<td>Dummy 1982</td>
<td>-0.0487(-1.98)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dummy 1992</td>
<td>-0.1411(-2.96)</td>
<td>-0.0599(-2.32)</td>
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<tr>
<td>ect_{t-1}</td>
<td>-0.3743(-4.50)</td>
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<td></td>
</tr>
</tbody>
</table>

Diagnostic Tests (p-values)
- Adjusted R^2: 0.57, 0.24, 0.38
- DW: 2.10, 2.13, 1.68
- Ramsey Reset Test: F-statistic 0.0006(0.99), 2.369(0.11), 0.948(0.94)
- Normality: 0.297(0.86), 1.1407(0.56), 3.3345(0.18)
- BG Serial Correlation LM Test: F-statistic 0.9256(0.40), 0.1808(0.67), 1.7222(0.18)
- ARCH Test: F-statistic 0.2760(0.60), 0.5334(0.46), 0.4274(0.51)

Note: Unless otherwise mentioned, figures in parentheses are t-statistics.

5. Conclusion and Policy Implications

This study used time series cointegration techniques to investigate the sectoral interrelationships among the agricultural, industrial and services sectors in Barbados over

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6 This is also evident from Figure 3B, where the effect of the shock to the agriculture equation is negligible (note that lagri is plotted on the right hand axis).
the past five decades. The complete data set was divided into two sub-samples: (1946-1969) and (1970-2003) to examine whether the commonly held view of the structural transformation from a predominantly agro-based economy to one that is increasingly service-oriented was represented in the data.

The main finding is that the sectoral linkages with agriculture appear to have faded over the years. In the first sub-sample, changes in agriculture output were determined by both industrial and services output, whereas in the second sub-sample, industry assume the passive role, reacting only to changes in services output. Therefore, in order to boost industrial output, services should be targeted, since the causal impact is stronger. Furthermore, agricultural GDP was not found to be part of the cointegrating system in the latter sub-period, suggesting little or no linkages with the industrial and services sectors. As such, the Government is not likely to achieve any substantial benefit across economic sectors by promoting agriculture.

The empirical results do not mean, however, that the agricultural sector does not contribute to economic output, employment and foreign exchange earnings. Indeed, over the past decade, export receipts from raw sugar have average US$25 million per year and slightly under 1,000 (local) persons are still directly employed in the sugar industry, which provides molasses for the manufacture of Barbados’ world famous rum. However, what they do suggest is that the links between that sector and the others are at best weak. Put differently, improvements in agriculture output do not necessarily lead to higher output levels in services or industry.

Thus, from an economic policy standpoint, the Government of Barbados should continue in earnest with its focus on the promotion of the export services sectors to lead the charge into the future.

References


Annex

Figure 2.
Figure 3: Persistence Profile of the effect of a system-wide shock to CV for the respective period.

Figure 3A: Generalised Impulse Responses of the CV (1946-1969) to one S.E. shock in the respective equations.

Figure 3B: Generalised Impulse Responses of the CV (1970-2003) to one S.E. shock in the respective equations.