
# ELASTICITIES AND BUOYANCIES OF THE BARBADOS TAX SYSTEM, 1977 – 1999

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**Abstract**

The paper evaluates the performance of the Barbados fiscal system over the period 1977 to 1999 based on estimates of revenue productivity. Short and long run elasticites and buoyancies are estimated for tax revenue, and the major components. The study finds that the elasticity of the tax regime tends to be more responsive to changes in gross domestic product in the short run but less so in the long run. Also, over the period under investigation, discretionary changes to the tax system seem to be effective, as buoyancies are generally higher than the elasticity coefficients.

**1. Introduction**

Tax elasticity and tax buoyancy are important tools in evaluating the effectiveness of a country's tax strategy. Tax elasticity measures the responsiveness of a tax system to changes in Gross Domestic Product (GDP), and is defined as the percentage change of tax revenue exclusive of discretionary changes (legal changes in tax structure and tax base etc) resulting from a one percent change in GDP. If an expansionary fiscal policy is used to generate growth in GDP, then an elasticity coefficient less than one signifies an inelastic system incapable of automatically meeting growth in fiscal expenditures. An elasticity value greater than unity indicates an elastic system that is able to meet rising expenditures, ceteris paribus.

The paper seeks to evaluate the performance of the Barbados fiscal system over the period 1977 to 1999, based on an analysis of tax revenue productivity. Short and long run elasticities and buoyancies are estimated for tax revenue and its main components of direct and indirect taxes.

Tax buoyancy is the percentage change in tax revenue (discretionary changes included) caused by a one percent change in GDP. A value less than one suggests a low tax elasticity and ineffective discretionary changes, whereas a value greater than one implies that discretionary changes are improving the responsiveness of the tax system. Hence, knowledge of the degree of responsiveness of tax revenue to GDP would enable the Government to make more accurate forecasts of revenue in order to improve fiscal management.

Buoyancies and elasticities can be calculated for the entire tax regime or for individual components such as income and consumption taxes. Generally regressive and specific taxes contribute to low elasticities and buoyancies. Hence, deflated values for these indicators suggest to policy makers that there are currently too many of these types of taxes being implemented.

A cursory view of the tax ratios over the period 1977 to 1999 gives some indication of the performance of the Barbados tax system. The total tax ratio rises steadily over the period of study, ranging from 22.8% in 1977 to 35.6% in 1999 (Appendix A, Graph 1). At the disaggregated level, the indirect tax ratio generally increases during the same period, from a low of 13% to a high of 26%; the rise is steady from 1977-1989, a reflection of the shift in government's fiscal stance in 1980 from more reliance on income taxation to expenditure taxation. However, it exhibits increased volatility over the nineties, which is partially attributed to the frequent changes to the plethora of consumption taxes before the introduction of VAT in 1997 (Appendix A, Graph 2). With respect to the direct tax ratio graph, there is a steady decline between 1978 and 1985, ranging from 13% to 9%, as the progressivity of the income tax system was gradually reduced. Nevertheless, in the period 1989 to 1999, the ratio steadily increases from 9% to 12%. Between 1985 and 1989, the direct tax ratio sharply dips to a low of 5%, mainly

reflecting the impact of the adjustment made to the income tax rates and bands in 1986 (Appendix A, Graph 3).

The paper improves on previous efforts by incorporating co-integration techniques, which provides both long run and short run estimates of elasticities and buoyancies. The document borrows heavily from the methodology presented in Mansfield (1972) and it proceeds as follows: section 2 provides a review of the previous literature in the area, section 3 outlines the model used, section 4 gives the methodology employed, while results and conclusions are given in sections 5 and 6, respectively.

**2. Literature Review**

There have been few empirical studies done on estimating the buoyancy and elasticity of Barbados's tax system. However, scholars such as Williams (2001) and Howard (1992 and 1979) have included estimates of buoyancy and elasticity in their treatise of the Barbados tax system and public finance.

Williams (2001) estimated the average tax buoyancy and the tax elasticity to be 1.14 for the period 1976 to1990. She also observed that indirect tax components such as stamp duties, levies, and consumption taxes were the major determinants of the tax buoyancy rate.

Williams employed standard methods to calculate tax elasticity. This involved cleaning the series of discretionary changes, and regressing tax on GDP using single equation ordinary least squares (OLS). Additionally, total tax elasticity was disaggregated into levies, direct taxes and stamp duty elasticities. She concluded that direct taxes had greater tax elasticity than indirect taxes, because there were subjected to fewer discretionary changes between 1976 and 1986.

Howard (1992) estimated Barbados's tax buoyancy to be 0.68 for the period 1974 to 1984. He employed the following simple linear regression model,

$$\log T_c = \log a + b \log y,$$

where $T_c$ is tax category, b is the buoyancy coefficient and y is the GDP. The buoyancy coefficient was statistically significant and the $R^2$ value exceeded 95%. Howard attributed the low tax buoyancy to structural and administrative factors. He also suggested that the growth of an underground economy might have reduced the revenue productivity of the tax base, thereby lowering the tax buoyancy.

In an earlier work, Howard (1979) estimated tax buoyancies for the period 1947 to 1964 using the aforementioned method. In this instance, he calculated the tax buoyancy to be 1.046, which implied that total tax revenue varied proportionally with income. Howard argued that the low flexibility of the income tax regime reduced the overall yield of the tax system.

Further afield, Mitchell and Andrews (1999) examined changes in tax buoyancies in the member countries of the Eastern Caribbean Central Bank (ECCB) over the period 1980 to 1997. They utilized a Box–Cox transformation and therefore did not pre-specify a

relationship between tax and GDP. Results indicated that an unrestricted model was the most appropriate functional specification of tax buoyancy for Anguilla, Antigua, Dominica, St. Kitts, St. Lucia and St. Vincent. The most appropriate regression equation of tax buoyancy for Montserrat was a restricted form in which both parameters were equal to an unrestricted parameter, while a simple linear model was specified for Grenada.

Tax buoyancy for Grenada over the period 1980 to 1997 was estimated to be 0.9192 and inter-temporal buoyancies were calculated for all the other islands. Mitchell and Andrews attempted to ascertain tax buoyancies of direct, domestic and international trade taxes using the unrestricted form of the model, but could not achieve convergence. Consequently, they imposed three restrictions on the transformation parameters, which were an equal power transformation, and the linear and double log forms. The first restriction was preferred over the other two for the buoyancy estimates for Dominica and, in the case of St. Lucia, for direct and domestic taxes. Tax buoyancies of the three aforementioned tax components were estimated for the remaining countries using either linear or double log linear specifications.

Mitchell and Andrews concluded that the tax buoyancy levels in the independent countries, with the exception of St. Kitts, declined over the period of study. However, buoyancies in the British dependent territories, Montserrat and Anguilla, were found to be quite high. Waning tax buoyancies in the independent nations were attributed to the change in emphasis from direct taxes to indirect taxes, whereas the high buoyancy coefficients in the dependent territories were attributed to superior administrative efficiency by the British Government.

Using a double log specification, Mansfield (1972) estimated tax buoyancy and elasticity for Paraguay's tax system from 1962 to 1970 in order to analyse revenue growth.

Before calculating the tax elasticity coefficient, Mansfield derived a tax revenue series with discretionary changes netted out by employing the Proportional Adjustment technique. This series was used in the regression.

Mansfield (1972) determined the elasticity and buoyancy coefficients to be 1.14 and 1.69 respectively, and both met statistically acceptable standards. Elasticity and buoyancy coefficients were also estimated and compared for important components of tax revenue such as income tax, wealth taxes and import taxes. The elasticities of the aforementioned components were further disaggregated into base-to-income elasticities and tax-to-base elasticities to compare the growth rates.

Mansfield (1972) concluded that the strong increase in the tax ratio over the period was primarily due to discretionary changes in the tax system. He deduced that they were necessary to improve the tax-to-base elasticities and to attain a higher elasticity value for the country's tax system.

**3. General Model**

The following relationship between tax revenue and GDP is assumed**:**

$$T = \alpha Y^{\beta}$$

Hence, the regression equation is specified as follows:

$$\log T = \log \alpha + \beta \log Y,$$

where T is annual tax revenue, Y is annual nominal GDP at factor cost and β is the elasticity or buoyancy coefficient.[1]

The Engle Granger procedure is performed to determine if log Y and log T are co-integrated. However, the ADF critical values in the econometric software package were not used, because they are inaccurate when testing for stationarity of residuals. Instead, the correlograms of the residuals are used to determine cointegration. Where appropriate, an error correction model (ECM) is specified and the maximum number of lags tested is one due to the shortness of the data set. The general ECM is as follows:

$\Delta \log T = \alpha_0 + \alpha_1 \Delta \log Y + \alpha_2 \Delta \log Y_{-1} + \alpha_3 \Delta \log T_{-1} + \alpha_4 (\log T_{-1} - C - \beta \log Y_{-1}) + \varepsilon_t$

OLS is employed to estimate the short and long run values for elasticity and buoyancy. Afterwards, along with the standard diagnostics, a test of the cumulative sum of the squared recursive residuals and the Recursive Residual test are used to determine parameter constancy.

[1] If discretionary tax changes are netted out of the tax revenue series then β is the elasticity coefficient, otherwise it is the buoyancy coefficient.

**4. Methodology For Cleaning Tax Revenue Series**

Annual tax revenue and GDP data over the period 1977 to 1999 are collected from the relevant issues of the Annual Statistical Digest, published by the Central Bank of Barbados. The tax revenue data are transformed from fiscal year format, as recorded in the Annual Statistical Digest, to calendar year format before it is used, in order to be consistent with the calendar year estimates of nominal GDP. The discretionary changes data are collected from the Annual Budgetary Proposals over the same period.

Prest's (1962) method of netting out discretionary changes from the annual tax revenue series is employed. This procedure, also known as the Proportional Adjustment approach, is a technique of approximately deriving a tax revenue series measured with respect to a constant tax structure. The following variables are used in the process:

$T_i$: actual tax revenue for the ith year.

$D_i$: net discretionary change for the ith year.

$T_{ij}$: tax revenue in the jth year with respect to the existing tax structure in the ith year.

If i = 1, then $T_{1,1}, T_{1,2}, \ldots, T_{1,n}$ represents the annual tax revenue for n years with respect to the tax structure existing in year one. In other words all discretionary changes are netted out of the tax series after year one. This series is utilised in the elasticity calculations. The mathematical derivation is shown below:

$T_{1,1} = T_1$

$T_{1,2} = T_2 - D_2$

$T_{1,3} = T_{2,3} * T_{1,2} / T_2$

$T_{1,4} = T_{3,4} * T_{1,3} / T_3$

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$T_{1,j} = T_{j-1,j} * T_{1,j-1} / T_{j-1}$

The derivation of $T_{1,1}$ and $T_{1,2}$ is obvious and requires no further exposition[2]. However, the concept behind the derivation of $T_{1,3}$, $T_{1,4}$, …, $T_{1,n}$ demands further explanation. Hence, as an example, the derivation of $T_{1,3}$ will be analysed in detail. The analysis can easily be modified to accommodate the derivation of subsequent years, $T_{1,4}$, $T_{1,5}$, etc.

The derivation of $T_{1,3}$ can also be expressed as:

$T_{1,3} = T_{1,2} + ( T_{2,3} - T_2 ) * T_{1,2} / T_2$ .

A little algebraic manipulation will show that it is equivalent to the expression given originally. However, it is easier to understand the ideological framework underlying the methodology by using this alternate formula.

The concept is as follows: To derive $T_{1,3}$,

1) Calculate the change in tax revenue from year two to year three, relative to year two's tax structure: $T_{2,3} - T_2$
2) Find how many tax revenue dollars under year two's tax structure is equivalent to one dollar under year one's tax structure:

   $T_{1,2} = K * T_2$

   $K = T_{1,2} / T_2$

   So to find the increase in tax revenue from year two to year three with respect to year one's tax structure, multiply the amount found in step 1 by K.
3) Now, to arrive at an estimation for $T_{1,3}$ add the amount calculated in step 2 to $T_{1,2}$.

   (Tax revenue in year 3 w.r.t. year 1's tax structure) = (Tax revenue in year 2 w.r.t year 1's tax structure) + (Increase in tax revenue from year 2 to year 3 w.r.t. year 1)

**5. Results**

Error correction models (ECM) are utilised to estimate all of the elasticity and buoyancy values; all but direct tax elasticity and buoyancy models are statistically significant, and the parameters are constant over the period of study. It is observed that the direct tax revenue series dipped sharply between the period 1985 to 1989, and therefore this period is modelled by a dummy variable. The dummy variable is one between the aforementioned period and zero elsewhere. After this inclusion, the standard diagnostic results for the direct tax elasticity and buoyancy ECMs improved. It is believed that the sweeping reforms of the direct tax system during this period drastically lowered the direct tax revenue. Following is a report of all the results.

[2] In this study, base year 1 is 1977

Total Tax

The long and short run tax elasticities over the reviewed period are 0.93 and 1.07 respectively (Table 1). Consequently, it can be inferred that the tax system is fairly elastic in the short-run, but marginally inelastic in the long run. Additionally, the speed of adjustment coefficient suggests that approximately 52% of any discrepancy between the actual and the long-run value of tax revenue is eliminated each year (Appendix D, Table 2).

The short and long-run tax buoyancies of 1.11 and 1.32 (Table 1) over the period under study point to a relatively buoyant tax system; since they are higher than their elasticity counterparts, one can deduce that the discretionary changes were effective in increasing the responsiveness of the tax system. In this case, the speed of adjustment is 30% per annum (Appendix D, Figure 1). Clearly, the increase in responsiveness occurs at the expense of a slower rate of re-adjustment to equilibrium.

Indirect Taxes

In the long run, indirect taxes proved to be fairly unresponsive (0.70), whereas the short run elasticity was quite high (1.14). Results indicate that 35% of the divergence of current indirect tax revenue from the long run value is reduced each year (Appendix D, Figure 3). The corresponding buoyancies of 1.54 and 1.22 signify increased responsiveness of indirect taxes, and demonstrate the efficacy of the discretionary changes. Additionally, 40% of the disequilibrium between current and long run revenue is reduced each year (Appendix D, Figure 4). So, in the case of indirect taxes, discretionary changes result in both increased responsiveness of tax revenue and a faster rate of return to long run equilibrium.

Direct Taxes

For direct taxes, the long run tax elasticity is highly elastic, but the short run coefficient reflects low responsiveness (Table 1). However, with the inclusion of discretionary changes the long run and the short run coefficients converge to unity (see Table 1). In the case of the direct tax elasticity ECM, the speed of adjustment is 34% (Appendix D, Figure 5) whereas for the tax buoyancy ECM, it is 56% (Appendix D, figure 6). Hence, it is evident that the addition of discretionary changes decreases the long run responsiveness of direct taxes, but increases the rate of return to equilibrium.

All of the ECMs satisfied the standard regression assumptions, and the parameters were statistically stable, according to the Cumulative Sum of Squares test and the Recursive Residuals test of stability.

**Table 1**

| | Elasticity Coefficient | | Bouyancy Coefficient | |
|---|---|---|---|---|
| | Long Run | Short Run | Long Run | Short Run |
| Indirect Tax | 0.7 | 1.14 | 1.54 | 1.22 |
| Direct Tax | 1.49 | 0.89 | 0.99 | 1.05 |
| Total Tax | 0.93 | 1.07 | 1.32 | 1.11 |

A Chow break point test was performed to ascertain whether the introduction of VAT in 1997 had any significant impact on the elasticity and buoyancy estimations, but it was found to be statistically insignificant. Since VAT was recently instituted, this result is not surprising; future tests are likely to yield different results.

**6. Conclusion**

Notwithstanding the direct tax elasticity and buoyancy results, it appears that an inelastic tax system can be rendered more responsive with the application of judicious discretionary changes. However, there seems to be a trade off between a more responsive tax regime with respect to GDP and the rate of return to equilibrium, following a shock to the long-run position. The higher short-run elasticities for total taxes and indirect taxes, when compared to their respective long run counterparts, suggest that it may be unnecessary for the fiscal policy makers to tinker with the taxes in response to transitory circumstances.

The low long run tax elasticity of the indirect taxes implies that there were too many inefficient taxes. However, with the introduction of VAT in 1997, it is hoped that the responsiveness of indirect tax revenue would increase and thereby obviate the need for frequent discretionary changes, as was customary. In contrast, the high elasticity of direct taxes vis-à-vis the low buoyancy coefficient suggests that the direct tax system is becoming more regressive in nature when discretionary changes are made. Thus, it is not totally outrageous to deduce that the direct taxes may lack vertical equity. Nevertheless, this inference must be tempered with caution, because a further study in the equity of the direct tax system would be needed before a definitive verdict can be asserted.

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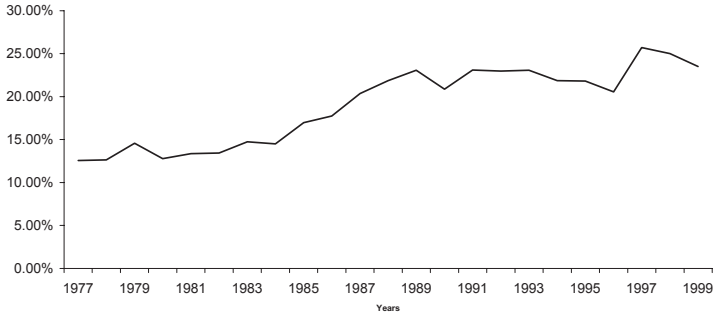
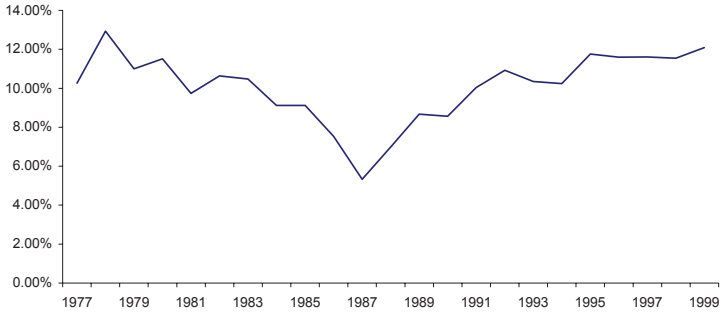
## APPENDIX A

**Graph 1: Total Tax Ratios from 1977-1999**


**Graph 2: Indirect Tax Ratios from 1977-1999**



**Graph 3: Direct Tax Ratios from 1977-1999**




**APPENDIX B**

**Order of Integration Tests**

| | Variable | | | | | | |
|---|---|---|---|---|---|---|---|
| Null Hypothesis | y | ctt | utt | cdt | udt | cit | uit |
| I(1) | -2.44<br>(-3.01) | -0.72<br>(-3.02) | -1.14<br>(-3.02) | -1.05<br>(-3.01) | -1.23<br>(-3.00) | -2.05<br>(-3.03) | -1.33<br>(-3.02) |
| I(2) | -3.92<br>(-3.03) | -2.10<br>(-1.96) | -3.05<br>(-3.03) | -3.08<br>(-3.02) | -4.97<br>(-3.01) | -3.82<br>(-3.01) | -4.16<br>(-3.01) |

Notes:
ctt: log of cleaned total taxes.
utt: log of uncleaned total taxes.
cdt: log of cleaned direct taxes.
udt: log of uncleaned direct taxes.
cit: log of cleaned indirect taxes.
uit: log of uncleaned indirect taxes.
y: log of GDP.

For each hypothesis, two values are given for each variable: the ADF test statistic and the ADF critical value at the 5% level in parenthesis.

**APPENDIX C**

*Testing cointegration using the Engle and Granger procedure*

**Table 1: Cointegration of ctt and y**

Dependent Variable: ctt
Method: Least Squares
Date: 02/06/03 Time: 19:12
Sample: 1977 1999
Included observations: 23
Newey-West HAC Standard Errors & Covariance (lag truncation=2)

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | -0.883767 | 0.319500 | -2.766093 | 0.0116 |
| y | 0.925573 | 0.042764 | 21.64354 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.965335 | Mean dependent var | 6.283092 |
| Adjusted R-squared | 0.963684 | S.D. dependent var | 0.392259 |
| S.E. of regression | 0.074752 | Akaike info criterion | -2.266341 |
| Sum squared resid | 0.117345 | Schwarz criterion | -2.167602 |
| Log likelihood | 28.06292 | F-statistic | 584.7903 |
| Durbin-Watson stat | 0.909938 | Prob(F-statistic) | 0.000000 |

**Table 2: Correlogram of residuals of regression above**

Sample: 1977 1999
Included observations: 23

| Autocorrelation | Partial Correlation | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|---|
| . \|**** \| | . \|**** \| | 1 | 0.483 | 0.483 | 6.1085 | 0.013 |
| . \|**. \| | . \| . \| | 2 | 0.227 | -0.009 | 7.5160 | 0.023 |
| . *\| . \| | .**\| . \| | 3 | -0.063 | -0.220 | 7.6283 | 0.054 |
| . *\| . \| | . \| . \| | 4 | -0.104 | 0.014 | 7.9569 | 0.093 |
| .**\| . \| | .**\| . \| | 5 | -0.292 | -0.262 | 10.688 | 0.058 |
| . *\| . \| | . \|* . \| | 6 | -0.157 | 0.106 | 11.527 | 0.073 |
| .**\| . \| | .**\| . \| | 7 | -0.284 | -0.277 | 14.433 | 0.044 |
| .**\| . \| | .**\| . \| | 8 | -0.294 | -0.197 | 17.740 | 0.023 |
| .**\| . \| | . \|* . \| | 9 | -0.202 | 0.086 | 19.421 | 0.022 |
| . \| . \| | . \| . \| | 10 | -0.022 | -0.055 | 19.442 | 0.035 |
| . \| . \| | . *\| . \| | 11 | -0.013 | -0.075 | 19.450 | 0.053 |
| . \| . \| | . *\| . \| | 12 | 0.054 | -0.069 | 19.604 | 0.075 |

**Table 3: Cointegration of utt and y**

Dependent Variable: utt
Method: Least Squares
Sample: 1977 1999
Included observations: 23

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | -3.727603 | 0.379931 | -9.811251 | 0.0000 |
| y | 1.320311 | 0.048999 | 26.94567 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.971890 | Mean dependent var | 6.495777 |
| Adjusted R-squared | 0.970552 | S.D. dependent var | 0.557659 |
| S.E. of regression | 0.095697 | Akaike info criterion | -1.772313 |
| Sum squared resid | 0.192317 | Schwarz criterion | -1.673575 |
| Log likelihood | 22.38160 | F-statistic | 726.0693 |
| Durbin-Watson stat | 0.633388 | Prob(F-statistic) | 0.000000 |

**Table 4: Correlogram of residuals**

Date: 03/06/03 Time: 17:23
Sample: 1977 1999
Included observations: 23

| Autocorrelation | Partial Correlation | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|---|
| . \|***** \| | . \|***** \| | 1 | 0.667 | 0.667 | 11.624 | 0.001 |
| . \|*** \| | . *\| . \| | 2 | 0.401 | -0.078 | 16.037 | 0.000 |
| . \|**. \| | . \| . \| | 3 | 0.251 | 0.027 | 17.853 | 0.000 |
| . \|* . \| | . *\| . \| | 4 | 0.114 | -0.083 | 18.249 | 0.001 |
| . \| . \| | . *\| . \| | 5 | -0.045 | -0.148 | 18.315 | 0.003 |
| . *\| . \| | . \| . \| | 6 | -0.093 | 0.040 | 18.605 | 0.005 |
| ***\| . \| | ***\| . \| | 7 | -0.323 | -0.433 | 22.363 | 0.002 |
| ***\| . \| | . \| . \| | 8 | -0.396 | 0.059 | 28.370 | 0.000 |
| ***\| . \| | . *\| . \| | 9 | -0.371 | -0.079 | 34.030 | 0.000 |
| ***\| . \| | . *\| . \| | 10 | -0.340 | -0.064 | 39.148 | 0.000 |
| ***\| . \| | . *\| . \| | 11 | -0.346 | -0.082 | 44.869 | 0.000 |
| .**\| . \| | . \| . \| | 12 | -0.226 | 0.010 | 47.528 | 0.000 |

**Table 5: Cointegration of cit and y**

Dependent Variable: cit
Method: Least Squares
Sample: 1977 1999
Included observations: 23

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.035952 | 0.537877 | 0.066841 | 0.9473 |
| y | 0.704619 | 0.069369 | 10.15756 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.830885 | Mean dependent var | 5.491925 |
| Adjusted R-squared | 0.822832 | S.D. dependent var | 0.321873 |
| S.E. of regression | 0.135481 | Akaike info criterion | -1.077037 |
| Sum squared resid | 0.385454 | Schwarz criterion | -0.978298 |
| Log likelihood | 14.38592 | F-statistic | 103.1760 |
| Durbin-Watson stat | 0.617085 | Prob(F-statistic) | 0.000000 |

**Table 6: Correlogram of residuals**

Sample: 1977 1999
Included observations: 23

| Autocorrelation | Partial Correlation | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|---|
| . \|***** \| | . \|***** \| | 1 | 0.672 | 0.672 | 11.819 | 0.001 |
| . \|***  \| | . *\| .  \| | 2 | 0.414 | -0.070 | 16.512 | 0.000 |
| .  \|  .  \| | ***\| .  \| | 3 | 0.053 | -0.362 | 16.593 | 0.001 |
| . *\| .  \| | .  \|* .  \| | 4 | -0.066 | 0.130 | 16.726 | 0.002 |
| .**\| .  \| | .**\| .  \| | 5 | -0.259 | -0.256 | 18.875 | 0.002 |
| .**\| .  \| | .  \|  .  \| | 6 | -0.239 | 0.063 | 20.800 | 0.002 |
| ***\| .  \| | ***\| .  \| | 7 | -0.389 | -0.350 | 26.251 | 0.000 |
| ***\| .  \| | .  \|  .  \| | 8 | -0.361 | -0.029 | 31.239 | 0.000 |
| ***\| .  \| | .  \|  .  \| | 9 | -0.353 | 0.021 | 36.371 | 0.000 |
| . *\| .  \| | .  \|  .  \| | 10 | -0.166 | -0.012 | 37.592 | 0.000 |
| . *\| .  \| | .  \|  .  \| | 11 | -0.092 | -0.043 | 37.997 | 0.000 |
| .  \|  .  \| | . *\| .  \| | 12 | 0.029 | -0.131 | 38.039 | 0.000 |

**Table 7: Cointegration of uit and y**

Dependent Variable: uit
Method: Least Squares
Sample: 1977 1999
Included observations: 23

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | -2.003264 | 0.820519 | -2.441461 | 0.0236 |
| y | 0.960156 | 0.105821 | 9.073429 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.796762 | Mean dependent var | 5.431378 |
| Adjusted R-squared | 0.787084 | S.D. dependent var | 0.447897 |
| S.E. of regression | 0.206672 | Akaike info criterion | -0.232422 |
| Sum squared resid | 0.896983 | Schwarz criterion | -0.133683 |
| Log likelihood | 4.672854 | F-statistic | 82.32711 |
| Durbin-Watson stat | 0.521420 | Prob(F-statistic) | 0.000000 |

**Table 8: Correlogram of residuals**

Sample: 1977 1999
Included observations: 23

| Autocorrelation | Partial Correlation | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|---|
| . \|****** \| | . \|****** \| | 1 | 0.767 | 0.767 | 15.357 | 0.000 |
| . \|*****  \| | .  \|  .  \| | 2 | 0.603 | 0.037 | 25.302 | 0.000 |
| . \|***  \| | . *\| .  \| | 3 | 0.445 | -0.069 | 30.990 | 0.000 |
| . \|***  \| | .  \|  .  \| | 4 | 0.345 | 0.038 | 34.591 | 0.000 |
| . \|**.  \| | . *\| .  \| | 5 | 0.240 | -0.060 | 36.429 | 0.000 |
| . \|**.  \| | . \|* .  \| | 6 | 0.200 | 0.078 | 37.785 | 0.000 |
| . \|* .  \| | .  \|  .  \| | 7 | 0.151 | -0.023 | 38.608 | 0.000 |
| . \|* .  \| | . *\| .  \| | 8 | 0.079 | -0.105 | 38.846 | 0.000 |
| .  \|  .  \| | .  \|  .  \| | 9 | 0.014 | -0.033 | 38.855 | 0.000 |
| . *\| .  \| | . *\| .  \| | 10 | -0.064 | -0.100 | 39.035 | 0.000 |
| .**\| .  \| | .**\| .  \| | 11 | -0.230 | -0.309 | 41.570 | 0.000 |
| .**\| .  \| | .  \|  .  \| | 12 | -0.304 | 0.019 | 46.397 | 0.000 |
| .**\| .  \| | .  \|** .  \| | 13 | -0.253 | 0.230 | 50.084 | 0.000 |
| .**\| .  \| | . *\| .  \| | 14 | -0.259 | -0.156 | 54.386 | 0.000 |
| .**\| .  \| | . *\| .  \| | 15 | -0.266 | -0.069 | 59.476 | 0.000 |
| .**\| .  \| | .  \|  .  \| | 16 | -0.274 | -0.041 | 65.640 | 0.000 |
| .**\| .  \| | . *\| .  \| | 17 | -0.305 | -0.127 | 74.560 | 0.000 |
| ***\| .  \| | .  \|  .  \| | 18 | -0.343 | -0.025 | 88.128 | 0.000 |
| ***\| .  \| | .  \|  .  \| | 19 | -0.323 | 0.043 | 103.11 | 0.000 |
| .**\| .  \| | . *\| .  \| | 20 | -0.314 | -0.098 | 122.01 | 0.000 |

**Table 9: Cointegration of cdt and y**

Dependent Variable: cdt
Method: Least Squares
Sample: 1977 1999
Included observations: 23

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | -5.622678 | 0.460327 | -12.21453 | 0.0000 |
| y | 1.487859 | 0.059516 | 24.99937 | 0.0000 |
| d | -0.259049 | 0.058761 | -4.408532 | 0.0003 |

| | | | |
|---|---|---|---|
| R-squared | 0.969152 | Mean dependent var | 5.841735 |
| Adjusted R-squared | 0.966067 | S.D. dependent var | 0.627621 |
| S.E. of regression | 0.115614 | Akaike info criterion | -1.356012 |
| Sum squared resid | 0.267332 | Schwarz criterion | -1.207904 |
| Log likelihood | 18.59413 | F-statistic | 314.1650 |
| Durbin-Watson stat | 1.561935 | Prob(F-statistic) | 0.000000 |

Note
d is a step dummy variable. It is 1 between 1985 and 1989, and 0 elswhere.

**Table 10: Correlogram of residuals**

Sample: 1977 1999
Included observations: 23

| Autocorrelation | Partial Correlation | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|---|
| . \|** . \| | . \|** . \| | 1 | 0.209 | 0.209 | 1.1393 | 0.286 |
| . \| . \| | . *\| . \| | 2 | -0.020 | -0.067 | 1.1504 | 0.563 |
| . \|** . \| | . \|*** \| | 3 | 0.323 | 0.359 | 4.1573 | 0.245 |
| . \| . \| | . *\| . \| | 4 | 0.038 | -0.144 | 4.2007 | 0.380 |
| ***\| . \| | .**\| . \| | 5 | -0.338 | -0.317 | 7.8571 | 0.164 |
| . \| . \| | . \| . \| | 6 | 0.005 | 0.064 | 7.8580 | 0.249 |
| . \|* . \| | . \|* . \| | 7 | 0.119 | 0.120 | 8.3693 | 0.301 |
| .**\| . \| | . \| . \| | 8 | -0.193 | -0.042 | 9.8007 | 0.279 |
| . *\| . \| | .**\| . \| | 9 | -0.179 | -0.203 | 11.115 | 0.268 |
| . \| . \| | .**\| . \| | 10 | -0.036 | -0.199 | 11.171 | 0.344 |
| . *\| . \| | . \| . \| | 11 | -0.132 | 0.019 | 12.011 | 0.363 |
| .**\| . \| | . *\| . \| | 12 | -0.315 | -0.143 | 17.193 | 0.142 |

**Table 11: Cointegration of udt and y**

Dependent Variable: udt
Method: Least Squares
Sample: 1977 1999
Included observations: 23

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | -2.156192 | 0.494444 | -4.360839 | 0.0003 |
| y | 0.987921 | 0.063846 | 15.47342 | 0.0000 |
| d2 | -0.475770 | 0.077203 | -6.162558 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.929890 | Mean dependent var | 5.431378 |
| Adjusted R-squared | 0.922879 | S.D. dependent var | 0.447897 |
| S.E. of regression | 0.124384 | Akaike info criterion | -1.209782 |
| Sum squared resid | 0.309427 | Schwarz criterion | -1.061674 |
| Log likelihood | 16.91249 | F-statistic | 132.6335 |
| Durbin-Watson stat | 1.724407 | Prob(F-statistic) | 0.000000 |

Note
d2 is a step dummy. It is 1 from 1986 to 1988, and 0 elsewhere.

**Table 12: Correlogram of residuals.**

Sample: 1977 1999
Included observations: 23

| Autocorrelation | Partial Correlation | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|---|
| . \|* . \| | . \|* . \| | 1 | 0.102 | 0.102 | 0.2725 | 0.602 |
| . \|** . \| | . \|** . \| | 2 | 0.293 | 0.286 | 2.6265 | 0.269 |
| . \|* . \| | . \|* . \| | 3 | 0.146 | 0.105 | 3.2389 | 0.356 |
| . \|* . \| | . \| . \| | 4 | 0.090 | -0.010 | 3.4814 | 0.481 |
| . \| . \| | . *\| . \| | 5 | -0.044 | -0.133 | 3.5443 | 0.617 |
| . \| . \| | . \| . \| | 6 | -0.014 | -0.051 | 3.5513 | 0.737 |
| .**\| . \| | .**\| . \| | 7 | -0.216 | -0.198 | 5.2327 | 0.632 |
| . *\| . \| | . \| . \| | 8 | -0.075 | -0.022 | 5.4464 | 0.709 |
| .**\| . \| | . *\| . \| | 9 | -0.267 | -0.156 | 8.3743 | 0.497 |
| . *\| . \| | . \| . \| | 10 | -0.127 | -0.036 | 9.0868 | 0.524 |
| .**\| . \| | . *\| . \| | 11 | -0.263 | -0.144 | 12.394 | 0.335 |
| .**\| . \| | .**\| . \| | 12 | -0.246 | -0.197 | 15.552 | 0.213 |

**APPENDIX D:**

*The ECMS and diagnostic results*

**Figure 1: ECM for cleaned total taxes**

D(ctt) = 1.07*D(y) - 0.52*(ctt(-1)-.93*y(-1)+.88)
(7.46) (-2.76)

$R^2$ = 0.58 , adj $R^2$ = 0.56, P( F-statistic) = 0.000039
P(JB-statistic) = 0.83, P(WH-statistic) = 0.74
P(LM-statistic) = 0.73

**Figure 2: ECM for uncleaned total taxes**

D(utt) = 1.11*D(y) - 0.30*(utt(-1)-1.32*y(-1)+3.73)
(7.06) (-1.90)

$R^2$ = 0.37, adj $R^2$ = 0.34, P(F-statistic) = 0.0027
P(JB-statistic) = 0.68, P(WH-statistic) = 0.31
P(LM-statistic) = 0.54

**Figure 3: ECM for cleaned indirect taxes**

D(cit) = -0.02+ 1.14*D(y) - 0.35*(cit(-1)-.70*y(-1)-.036)
(-0.75) (3.37) (-2.17)

$R^2$ = 0.43, adj $R^2$ = 0.37, P(F-statistic) = 0.0047
P(JB-statistic) = 0.63, P(WH-statistic) = 0.79
P(LM-statistic) = 0.69

**Figure 4: ECM for uncleaned indirect taxes**

D(uit) = 1.22*D(y) - 0.40*(uit(-1)-1.54*y(-1)+5.90)
(6.42) (-2.41)

$R^2$ = 0.41, adj $R^2$ = 0.38, P(F-statistic) = 0.0014
P(JB-statistic) = 0.75, P(WH-statistic) = 0.06
P(LM-statistic) = 0.45

**Figure 5: ECM for cleaned direct taxes**

D(cdt) = 0.04 + 0.89*D(y) - 0.34*(cdt(-1)-1.49*y(-1)+0.26*D(-1)+5.62)
(1.30) (2.52) (-1.69)

$R^2$ = 0.27, adj $R^2$ = 0.20, P(F-statistic) = 0.0014
P(JB-statistic) = 0.75, P(WH-statistic) = 0.047
P(LM-statistic) = 0.80

**Figure 6: ECM for uncleaned direct taxes**

D(udt) = 1.05*D(y) - 0.56*(udt(-1)-0.99*y(-1)+0.48*D(-1)+2.16)
(3.20) (-2.07)

$R^2$ = 0.19, adj $R^2$ = 0.15, P(F-statistic) = 0.04
P(JB-statistic) = 0.77, P(WH-statistic) = 0.69
P(LM-statistic) = 0.47

Notes:
D: dummy variable.
D={1, for 1985 to 1989; 0, elsewhere}.
P(JB-statistic): p-value of the Jarque-Bera statistic.
P(WH-statistic): p-value of the White Heteroscedasticity statistic.
P(LM-statistic): p-value of the Lagrange Multiplier statistic.

***APPENDIX E***

Significant (over $500 000) discretionary changes over the period 1977 to 1999

1977/78:

- Restoration of partial tax credit for dividends distributed to resident shareholders, and restrictions on loans to Directors and imposition of withholding tax on after-tax profits of branches of non-resident companies. Estimated to cost $1m.
- A tax credit to be granted to all taxpayers with gross income less than $5oo a month. Estimated to cost $2m.
- Increase in tax on motor vehicles from 40% to 45%. Estimated to yield $1m.
- 10% levy on overseas telephone calls. Estimated revenue $500 000.
- Increase in consumption tax on 38 items. Estimated yield $1.6m.
- Increase in the rate of motor vehicle tax from 20% to 30%. Estimated revenue $900 000.
- Increase in Hotel, Restaurant and Sales tax from 5% to 8%. Increase yield by $2.4m.
- Increase in taxes on pool betting duties, racing service registration, sweepstakes, bingo and entertainment. Estimated yield $856 000.

1978/79:

- Extension of income tax credit. Estimated cost $1.8.
- Increase in the rate of excise duty on rum. Estimated yield $1m.
- Increase of taxes on motor spirits. Estimated yield of $1.9m.

1979/1980:

- Duty Concessions on taxis. Estimated cost $0.6m.
- Income tax concessions and concessions for savings, house building and salaries. Estimated cost $11.4m.
- Increase of Consumption taxes. Estimated revenue $0.8m.
- Increase in tax on petroleum products. Estimated revenue $2.2m.
- Increase in land tax. Estimated revenue $1.5m.

1980/1981:

- Increase tax credit. Expected cost $6.2m.
- Adjustment to income tax rates and taxable income bands. Expected cost $17.5m.
- Increase coverage of consumption tax. Expected revenue $21m.
- Increase consumption tax on alcoholic beverages. Expected yield $1.4m.
- Increase in tax on gas and diesel. Estimated yield $1.9m.
- Imposition of an 8% surcharge tax on proceeds from rental of self-drive cars. Expected revenue $600 000.
- Imposition of a through-put charge on fuel supplied to aircraft. Expected revenue $1.8m.

1981/1982:

- Increase in income tax allowances. Expected cost $16m.
- Abolition of Death Duties. Expected cost $2.2m.
- Increase in Property Transfer Tax. Expected revenue $750 000.

1982/1983:

- Introduction of a 3% surcharge on profits. Estimated yield $2m.
- Increase tax on insurance premiums. Estimated yield $500 000.
- Increase in excise and consumption taxes on liquor and cigarettes. Expected revenue $5.5m.
- Increase consumption taxes on miscellaneous articles of plastic and cosmetics. Expected yield $1.8m.
- Increase on petroleum taxes. Expected revenue $2.6m.
- Increase on consumption tax on motor vehicles. Expected revenue $1.6m.
- Increase stamp duty on Bills of Entry. Expected yield $8.5m.
- Increase fees for banking licences and the introduction of a tax on average assets for the previous year. Expected revenue $2.1m.

1983/1984:

- Consumption tax rates on motorcars. Expected cost $600 000.
- Reduction in income tax rates. Expected cost $2.7m.
- Consumption tax adjustments to gasoline, kerosene and fuel oil. Estimated revenue $5.1m.
- Stamp duty increase on documents processed by the Customs department and an increase on all Exempt Insurance documents. Estimated revenue $7m.
- Increase in Department Tax and Terminal Charge. Estimated revenue $1.4m.
- Increase Travel Tax on Airline tickets. Estimated yield $2m.
- Increase in Health Service charge. Expected revenue $6m.
- Increase land taxes applied to parcels of land owned by foreign companies. Expected yield $1.5m.

1984/1985:

- Increase in allowances for income tax. Expected cost $10.6m.
- Removal of temporary surcharge of 3% imposed on corporate profits. Expected loss $4m.
- Increase stamp duties on imported goods. Expected revenue $19m.
- Increase property transfer tax. Expected yield $1.8m.

- Increase taxes on Barbados Turf club tickets. Expected yield $2.34m.
- Increase in Departure tax. Expected revenue $1m.
- Adjustment to consumption tax. Expected revenue $2.7m.

1985/1986:

- Exemption from income tax 50% of royalty payments received in Barbados from sale of books, songs etc. Expected loss $3.3m.
- Building allowance on all commercial buildings. Expected cost $1.6m.
- Reduction of consumption tax on imported wines. Expected cost $1.3m.
- Increase of national training levy. Expected yield $2m.
- Increase in stamp duty. Expected revenue $10m.

1986/1987:

- A building allowance for listed properties of a commercial nature. Expected cost $800 000.
- Adjustment to income tax rates and bands. Expected cost $11.6m.
- Increase mortgage interest allowance. Expected loss $2m.
- Tax on improved value of the land reformulated. Expected cost $1.9m.
- Increased consumption tax on gasoline, kerosene, automotive and industrial diesels increased. Expected revenue $15m.
- Increase annual depreciation allowance. Revenue cost $1.6m.

1987/1988:

- Exemption of property transfer tax and stamp duty. Expected cost $500 000.
- Levies not allowed as a deduction for income tax purposes. Expected revenue $1.5m.
- Covenants, except for those with charitable organisatons, will be restricted to 5% of assessable income. Expected gain $500 000.
- Dividend credit reduced from 50% to 15%. Expected revenue $700 000.
- Building allowance for commercial buildings reduced from 2% to 1%. Expected revenue $750 000.
- Training levy implemented. Expected gain $2.75m.
- Employment levy. Expected revenue $9.2m.
- Health levy. Expected revenue $4.6m.
- Increase transport levy. Expected revenue $6.875m.
- A 2% reduction on stamp duty on Caricom imports, but a 3% increase on extra-regional imports. Expected revenue $11m.
- Increase in consumption taxes. Expected revenue $14m.
- Increase travel tax from 10% to 15%. Expected revenue $2m.

1988/1989:

- Stamp Duty on imports from Caricom region removed. Expected cost $20m.
- Removal of stamp duty on raw materials and packaging materials. Expected cost $35m.
- Introduction of health levy. Expected revenue $29.5m.
- Increase ad valorem consumption tax rates. Expected revenue $71m.

1989/1990:

- Removal of stamp duty on agricultural inputs. Expected revenue loss $3.7m.
- Import duty exemption for machinery and equipment for use in the manufacturing sector. Expected cost $4m.
- Increase consumption tax on motor vehicles. Expected loss $2m.
- Increase consumption tax on all other items. Expected revenue $36m.
- Stamp duty increase on non-Caricom imports. Expected revenue $12m.
- Increase in travel ticket tax. Expected revenue $2m.
- Increase airline service charges. Expected gain $2m.

1990/1991:

- Amendment to Income Tax act to permit data processing companies and companies that purchase wholesale from local companies exclusively for export, to benefit from the Export Allowance.
- Adjustments made to corporate taxes, travel ticket tax, and consumption tax.

Expected revenue $3.3m and expected loss $6m.

1991/1992:

- Introduction of a stabilization tax of 1.5%. Expected revenue $30m.
- Consumption taxes adjustments. Expected revenue $60m.
- Increase departure tax. Expected revenue $2.4m.

1992/1993:

- Consolidation of previous five tax brackets into two.
- Withholding taxes of 12.5% on interest payments and dividends.
- Elimination of most allowances and deductions provided for in previous years.
- Increase in corporate tax rate from 35% to 40%.

1993/1994:

- Removal of surcharge on Caricom imports. Expected cost $1.7m.
- Barbados Customs tariff revised. Expected loss $18m.
- All ad valorem rates on Consumption tax except in the case of liquefied gas and natural gas, increased by 4%. Expected revenue $18m.
- Specific rates of consumption tax on alcoholic beverages and tobacco increased. Expected revenue $6.3m.
- The effective rate of tax on insurance premiums changed. Expected gain $6m.

1994/1995:

- Stamp duty waived for agriculture and consumption tax waived on machinery and equipment. Expected loss $2.3m

1995/1996:

- Removal of consumption tax on fuel oil, industrial diesel and natural gas. Expected loss $3.6m.
- Consumption tax and surcharge removed from yachts and sporting vessels respectively. Expected loss $600 000.
- Removal of luxury tax and stamp duty on cars of 1600 cc or less. Expected loss $11m.
- Phasing out of surtax on imports. Expected revenue $6.2m.
- 5% charge of the value will be imposed at point of entry on articles destined for duty-free shops. Expected revenue $3m.
- Introduction of an environmental levies on several products. Expected revenue $2m.
- Tax per ticket for lotteries and sweepstakes and tax on Bingo tickets increase. Expected revenue $600 000.

1996/1997:

- Effective Jan 1, 1997. Introduction of VAT and abolition of 11 types of indirect tax. Expected cost $25m.

1997/1998:

- A zero rate of tax applied to several food items. Revenue cost $45m.
- Income tax adjustments. Expected loss $17m.

1998/1999:

- A reverse tax credit. Expected loss $10m.
- With effect from sept 3, 1998, for the period of one year, owners of property in Barbados shall be able to settle the outstanding indebtedness to the Commissioner of Land tax free from penalty and interest. Expected revenue loss $30m.
- Owed Consumption tax by the manufacturing sector written off. Expected loss $12m.

1999/2000:

- Reduction of excise tax on gasoline. Expected revenue loss $6m.
- Reduction of excise tax on gasoline. Expected cost $8.5m.
- New land tax rates. Expected revenue $3.2m.
- Imposition of CET rate of duty on imported lamb and beef. Expected revenue $7.3m.