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Estimating the Sizes of Buoyancy and Elasticity of the Tax System in Barbados Over the Period 1990 to 2019

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Abstract

Buoyancy and elasticity are important metrics to estimate the efficiency of a tax system, reflecting its capacity to collect tax revenue with minimal losses. The objective of this paper is to estimate the sizes of the buoyancy and elasticity of the tax system in Barbados in the period 1990 to 2019. The paper finds that total tax revenue is buoyant in the long-run and non-buoyant in the short run as well as elastic in the long run and inelastic in the short-run. Direct taxes are buoyant in the long-run and non-buoyant in the short-run while predominantly elastic in the long-run and inelastic in the short-run. Indirect Taxes are buoyant in the long-run and the short-run while elastic in the long-run and elastically inconclusive in the short-run. The low short-run estimations of direct taxes raise concerns about potential loopholes for tax evasion and obstructions to voluntary compliance by taxpayers. Failure to mitigate this may impair the government's ability to fully maximise its tax collection from direct taxes. Hence, it should prioritise assessing the current direct tax regime and determine whether information about tax registration is adequately circulated among the public.

JEL Classification: E62, H20, H21, H24, H25

Keywords: Total Tax Revenue, Direct Taxes, Indirect Taxes, Buoyancy, Elasticity

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1. Introduction

Many countries around the world have faced fiscal and debt challenges. In light of the ongoing COVID-19 crisis, global economic growth has contracted while fiscal deficits have risen to levels similar to that of the Global Financial Crisis of 2008. In the case of Barbados, the economic spillovers of reduced international travel and global shutdowns have considerably cut tourism activity and suspended investment opportunities. The country has turned to the International Monetary Fund (IMF) to help alleviate the recessionary effects of the crisis, albeit being subjected to restrictive guidelines to ensure repayment of the loan. Additionally, the Barbados Economic Recovery Transformation (BERT) program implemented with the support of the IMF, aided in the response to the crisis as it supported fiscal sustainability through generating revenue buffers and promoting the main objective of economic growth. Indeed, international reserves increased by over US$1 billion between May 2018 to October 2019 despite setbacks by the pandemic. It therefore, comes as no surprise that the IMF has projected nominal GDP growth to be 4.5% by 2024, an increase from -1.0% in 2019. Given this background, determining how economic growth can assist in relieving fiscal constraints[3] becomes an important aspect of allocating the budget for the future. Estimating the buoyancy and elasticity of the tax system is hence a useful framework necessary to achieve the goal sought.

Tax buoyancy and elasticity are measures of tax revenue sensitivity (elasticity) to a tax base that are broadly used to assess fiscal policy or the efficiency of a tax structure. Precisely, tax buoyancy is the response of revenue to a change (growth) in income (GDP) or another tax base where the change in revenue reflects both discretionary and automatic growth of revenue. Tax elasticity represents the automatic response of revenue to the change in income (GDP) or another tax base under an unchanged tax structure. As can be seen, although similar, tax elasticity differs from tax buoyancy in that it does not account for the potential effects of tax reforms on the tax revenues. In other words, while elasticities control for changes in tax policy, it is not the case for buoyancy estimates. Assessing the elasticity and buoyancy estimates contributes toward the growth and development strategy prepared by the Ministry of Finance, enabling the government to analyse and monitor the revenue side of the budget. They also allow future streams of tax revenue to be forecasted based on estimations using the historical trends of relevant macroeconomic variables, such as GDP or private consumption. Thus, accurate estimates of buoyancy and elasticity are important as it aids the government in avoiding unexpected falls in revenue while highlighting potential weaknesses within a tax structure. Without these estimates, it is expected that weaknesses in the tax system such as tax evasion or low voluntary compliance will go unnoticed, stifling the efficiency of revenue generation (Dudine and Jalles, 2017). Moreover, the fiscal balance is likely to be susceptible to deterioration through unexpected shocks caused by inadequately prepared budgets (Audi et al., 2021). Hence, identifying these issues becomes increasingly crucial bearing in mind that tax revenue has generated the majority of the fiscal revenue in Barbados over the past three decades.

The objective of this paper is to estimate the sizes of tax buoyancy and the elasticity of the tax system[4] in Barbados in the period 1990 to 2019. It examines the following question: How large are the short-run

[3] According to our calculation based on our estimation results, an economic growth of 4.5% would correspond to a tax revenue growth in the order of 3.7% to 5.8%.

[4] A tax system can be considered good when the buoyancy and elasticity coefficients are estimated to be one or more. A coefficient of over one suggests that as GDP grows, tax revenue will grow at a faster rate. A coefficient of less than one suggests

and long-run buoyancies and elasticities for total tax revenue and its main components (direct taxes and indirect taxes) in Barbados in the period of interest?

This research is a follow-up to a couple of papers dealing with the tax buoyancy (and elasticity) estimates of the tax system in Barbados. Scott-Joseph et al. (2016) among others derive the short-run and long-run estimates of tax buoyancy for Barbados in the period 1980-2014 using an error correction model approach. The results show a lack of buoyancy in all categories of taxes in the short run while in the long run, Income Tax and Land Tax show a lack of buoyancy. Skeete et al. (2003) assess the performance of the Barbados tax system over the period 1977-1999 by estimating the short and long-run elasticities and buoyancy of total tax revenue as well as its main components (direct and indirect taxes) using an error correction model approach. Both Total Tax Revenue and Indirect Taxes are buoyant in the short and long runs as well as elastic in the short run. Direct taxes are buoyant in the short run and elastic in the long run. Howard (1989) includes the estimates of tax buoyancy in his analysis of the public finance and tax system of Barbados over the period 1974 -1984. The results of the regression of the logged tax revenue variable on the logged GDP variable indicate that Income Tax and Total Tax Revenue lack buoyancy while Direct Taxes are buoyant.

Elsewhere, several studies have dealt with the topic of interest using various methodologies, particularly for calculating tax elasticity. Some studies have found the tax system in the respective countries of the study buoyant and elastic (i.e., Mansfield,1972; Choudhry, 1979; Yousuf and Huq, 2013; Cotton, 2012) and others non-buoyant and inelastic (i.e., Bilquees, 2004; Wolswijk, 2007).

As a core methodology, the present paper uses the autoregressive distributed lag model (ARDL) proposed by Pesaran et al. (2001) to obtain reliable estimates in the presence of nonstationary variables. In the context of generating elasticities, a tax variable is transformed by a double exponential smoothing technique to deal with discretionary tax changes or using, judiciously, a dummy variable capturing discretionary tax law changes to execute the core methodology. For note, recently, there have subsequently been numerous reforms and revisions to the Barbados taxation system that may alter the tax buoyancy and elasticity estimates previously calculated.

The study derives the following results: Total Tax Revenue is buoyant and elastic in the long run and non-buoyant and inelastic in the short run. Direct Taxes are buoyant and predominantly elastic in the long run and non-buoyant and inelastic in the short run. Indirect Taxes are buoyant and elastic in the long run and buoyant and elastically inconclusive in the short run.

This research makes the following contributions to the literature. First, the present paper is to the best of our knowledge only the second paper which deals with the buoyancy and elasticity of the tax system in Barbados. Its precursor, Skeete et al. (2003), indeed, needed to be amended in at least two domains (period of interest and methodology). Second, the study argues perhaps with Yousuf and Huq (2013) that creating a single dummy variable to capture multiple discretionary changes helps detract the issue of lost degrees of freedom which may render the use of dummy variables useless. Third, the paper also argues that appropriate exponential smoothing of tax variables can validly isolate discretionary tax changes. This is true as long as we equate discretionary tax changes with time series noise variation.

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that as GDP grows, tax revenue growth will lag. A coefficient of one indicates that GDP and tax revenues are unit elastic and will grow at the same rate (Mourre and Princen, 2015).

The paper is structured as follows: Section 2 gives an overview of the tax system in Barbados and highlights major trends in direct and indirect taxes. Section 3 provides a review of the previous literature in the area. Section 4 dwells on the methodology employed in the paper including the data used. Section 5 contains the buoyancy and elasticity estimates. Policy recommendations and conclusions are given in Section 6.

2. Overview of the Tax System in Barbados

Over the last three decades, Barbados has undergone numerous reforms intending to foster the simplicity of the tax system while broadening the tax base and promoting private investment. With this, reform would create more efficient taxes; that is, restructuring would reduce the loss of tax revenue associated with collecting taxes in inefficient tax structures while having positive implications for different aspects of the economy. Table 1 reflects the decomposition of the annual revenues generated as a percentage of GDP for the period 1990 to 2019.

Table 1: Composition of Tax Revenue in Barbados (1990-2019)

	Percentage of GDP				Percentage of GDP		
Period	Tax Revenue	Direct Taxes	Indirect Taxes	Period	Tax Revenue	Direct Taxes	Indirect Taxes
1990	21.5%	9.4%	12.1%	2005	24.2%	9.8%	14.4%
1991	23.8%	11.1%	12.8%	2006	25.8%	11.4%	14.4%
1992	23.5%	11.2%	12.3%	2007	24.7%	11.0%	13.7%
1993	22.6%	10.2%	12.4%	2008	24.9%	10.7%	14.1%
1994	21.7%	8.7%	13.0%	2009	24.7%	11.5%	13.2%
1995	23.2%	10.0%	13.3%	2010	24.2%	9.9%	14.3%
1996	22.4%	9.8%	12.6%	2011	24.7%	9.9%	14.8%
1997	26.3%	10.0%	16.3%	2012	24.4%	9.6%	14.8%
1998	24.7%	9.5%	15.2%	2013	22.8%	8.8%	14.0%
1999	24.3%	10.0%	14.3%	2014	24.5%	10.5%	14.0%
2000	25.5%	10.9%	14.6%	2015	22.7%	8.8%	13.8%
2001	26.2%	11.9%	14.4%	2016	24.2%	9.2%	14.9%
2002	25.0%	10.9%	14.1%	2017	27.5%	10.1%	17.3%
2003	26.3%	11.2%	15.2%	2018	26.5%	10.2%	16.3%
2004	25.8%	10.5%	15.3%	2019	27.2%	11.0%	16.2%

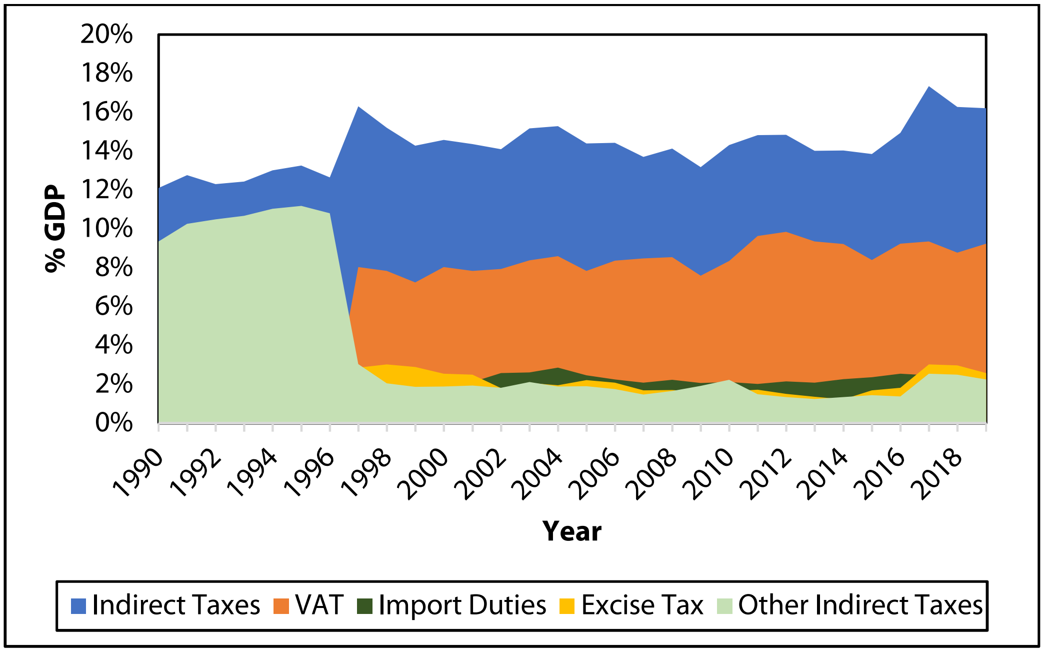
Sources: Accountant General, Ministry of Finance, Barbados Statistical Service, Author's Calculations

Tax revenue yielded revenues within the range of 21.5% to 27.5% of GDP. It flaunted a mean and median of 24.5% and 24.6%, respectively, along with an upward trend since 1990[5]. Likewise, Direct Taxes

[5] With a positive trend, Nominal GDP (in millions of Barbados dollars) ranged from 3901.800 (in 1992) to 10595.900 (in 2019) with a mean of 7317. 867 and a median of 7411.800.

exhibited an upward tendency with an equal mean and median of 10.2% and varied between 8.7% in 1994 and 11.9% in 2001. This category consisted mainly of Personal Income Tax (PIT), Corporate Income Tax (CIT), Property Tax (PT), and other forms of direct taxes. On the other hand, Indirect Taxes displayed a downward trend, ranging between 12.1% in 1990 to 17.3% in 2017 while its mean and median were akin at 14.2% and 14.3%. It comprised mainly of Value-Added Tax (VAT), Excise Tax (ET), Import Duties, and other forms of indirect taxes, as shown in Figure 1[6].

Figure 1: Major Categories of Indirect Taxes (% of GDP)



Sources: Accountant General, Ministry of Finance, Barbados Statistical Service, Author's Calculations

The share of Indirect Taxes to GDP remained relatively low until 1997, averaging around 12.6%, but picked up later into the late 1990s and early 2000s. This was largely attributed to tax reform in 1997, where the Government of Barbados sought to create a simplistic tax system. In doing so, eleven taxes levied on goods and services were eliminated and replaced by a VAT charged at 15%. Corresponding to the goals of the government, indirect taxes spiked by 3.7% of GDP from 1996 to 1997 primarily due to the reduction in the collection costs associated with having multiple tax categories. This upsurge was maintained over the following 7 years, averaging 14.8% of GDP compared to the 12.6% between 1990 to 1996, suggesting that VAT had vastly improved tax collection. Total Tax Revenue also jumped from 22.4% to 26.3% in 2019 in tandem with the spike in indirect taxes and remained relatively high compared to the previous years.

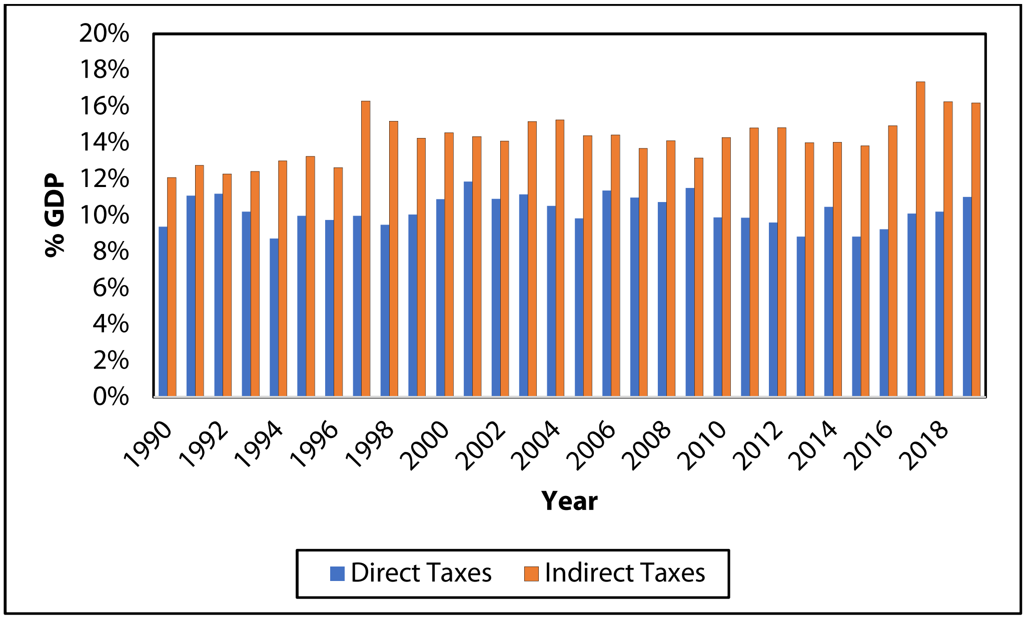
[6] The other indirect taxes categories include consumption tax, hotel & restaurant tax, customs, stamp duties, national social responsibility tax and other taxes on goods and services. However, many of these were eventually phase out in place of VAT. National social responsibility tax was introduced in 2017 and is imposed on all imported and domestically manufactured goods.

Throughout its lifespan, VAT has been the largest contributor to GDP and accounted for 8.5% of GDP on average. In 1999, VAT gradually declined to 7.2% of GDP from 8% recorded in 1997. This performance was the lowest share of GDP VAT amassed over the total period and carried on until 2001, averaging 7.8% over the four years. Given that there were no notable changes in VAT policy, it is unlikely this observation was caused by discretionary alterations. This led to indirect taxes experiencing a sharp fall from 16.3% in 1997 to 14.1% by 2002. Following 2002, VAT regained its upward momentum and remained relatively stable until 2009. It later dipped from 8.5% of GDP to 7.6% in 2009, coinciding with the global financial crisis of 2007-2009 that dampened all economic activity. To cope with the diminishing fiscal balances, the government of Barbados temporarily increased the VAT rate from 15% to 17.5% in 2010. VAT's contribution to GDP rose to 8.3% in 2010 and with this reform proving to be successful, the change was made permanent in 2011. VAT further increased by 1.3% of GDP in 2011 and remained relatively stable until 2019, fluctuating between 8.4% to 9.8%.

In 2017, indirect taxes spiked to 17.3% from 14.9% in the previous year. This increase was primarily caused by a rise in revenue collected from ET and other indirect taxes. The National Social Responsibility Levy (NSRL) was introduced in 2017 as a new category of indirect tax with the rate of 2% imposed on all imported and domestically manufactured goods distributed for commercial sale. This resulted in a 1.1% of growth in other indirect taxes to GDP in 2017. The contribution of this category remained moderately stable at 2.5% and 2.2% of GDP in the following two years despite the revision of the NSRL rate to 10% in 2018. Indeed, this feat was rarely achieved with the introduction of VAT in 1997. ET also experienced an upward trajectory since 2015 as a result of numerous revisions to ET policy, including a new 10% tax rate on sugar-sweetened beverages in 2015 and increased gasoline taxation in 2017. Import duties contributed a generous amount to indirect taxes, accounting for 2.2% of GDP on average over the past thirty years, ranging between 1.8% to 2.9% to remain the steadiest category of indirect taxes. Revisions to import policy mainly targeted the rates applied to agricultural imports, non-CARICOM imports and duty-free shopping domestically.

It is important to note the stability of direct taxes to GDP compared to indirect taxes from 1990 to 2019, narrowly fluctuating within a range of 8.7% to 11.9%, as shown in Figure 2. Direct tax accounted for 41.8% of total tax revenue. On average, personal income tax (PIT) was the largest contributor to GDP for direct taxes, accounting for 4.3% of GDP. Until 1993, PIT was administered in such a way that its tax revenue was lost in the collection process, particularly for high-income earners. This was mainly due to the numerous exemptions that high-income taxpayers benefitted from and levies that were applied to lower-income earners. This greatly hindered the progressivity and equitability of the regime and contributed to the relatively low PIT in the years 1990, 1991, and 1992, accounting for only 3.2%, 3.9%, and 3.2% of GDP, respectively. To improve the robustness of the tax regime, reform in 1993 reduced the number of tax brackets from six to two, with baseline rates of 25% for lower-income earners and 40% for higher-income earners. Further, a myriad of exemptions was eliminated to ensure the progressiveness of the regime. Resultingly, PIT increased in the decade following reform, with revenues gradually fluctuating to 5.0% of GDP in 2003.

Figure 2: Direct Taxes vs Indirect Taxes (% of GDP)



Sources: Accountant General, Ministry of Finance, Barbados Statistical Service, Author's Calculations

Direct taxes remained volatile despite PIT excelling between 1993 to 2003. This was attributed to a sudden drop-off in other direct taxes. Levies were a major contributor to the share of direct taxes to GDP and were imposed through taxation on imports, stabilisation tax, a training levy and numerous payroll levies. With the phasing out of stabilisation tax in 1995 and all payroll levies in 1995, other direct taxes dipped from an average of 2.6% to 0.9% in the years following 1995.

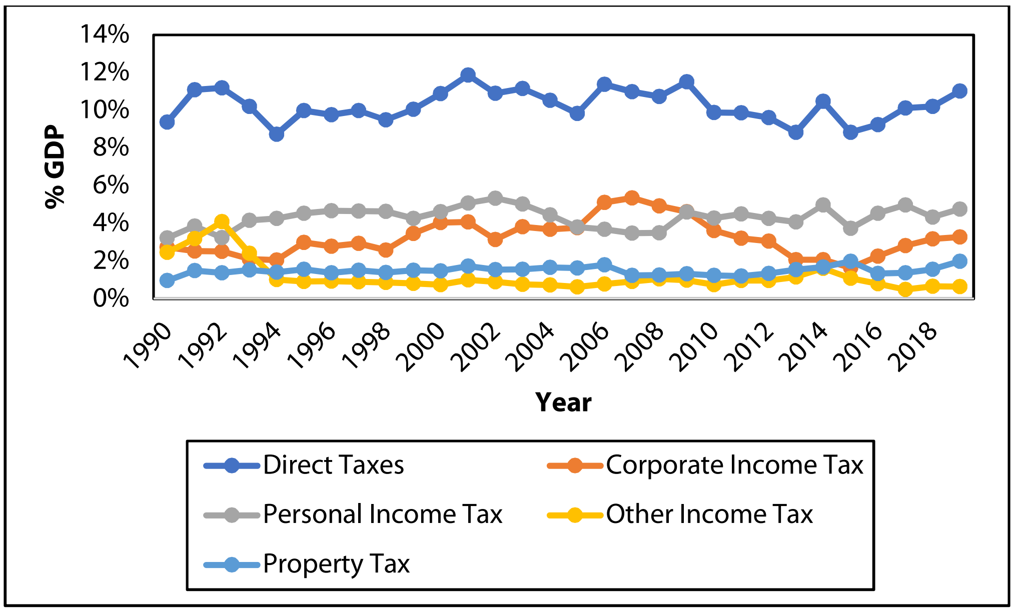
Direct taxes remained slightly volatile in the 2000s, moving in tandem with corporate income tax (CIT). The onset of the financial crisis in 2007 significantly impaired the revenues of corporations in Barbados, with CIT continuously plunging from a high of 5.3% in 2007 to a low of 1.6% in 2015. This drew the attention of the OECD, whose analysis of the country found that the CIT regime provided international companies with preferential rates[7] while promoting base erosion and profit shifting. Although CIT was slowly recovering over the following three years, the CIT regime was overhauled as part of the BERT program by the government of Barbados. CIT rates were reduced for domestic corporations, albeit administered in a regressive manner, contrary to the prior baseline model. Most importantly, CIT rates were equalised for domestic and international companies. The four new tax brackets established were taxed at rates of 5.5%, 3.0%, 2.5%, and 1.0% for corporations with profits below $1 million, $1 million to $20 million, $20 million to $30 million, and above $30 million, respectively. Thus, these low rates administered in a regressive manner were primarily observed to encourage international corporations to invest within the country. The results of this discretionary change were immediately noticeable in

[7] Prior to 2018, a CIT rate of 40% was imposed on corporation profits while insurance and construction companies received lower rates and exemptions. International corporations were at 2.5%, 2%, 1.5% and 0.25% for profits below BDS $10 million, between BDS $10 million to BDS $20 million, BDS $20 million to BDS $30 million and above BDS $30 million, respectively.

2018, as CIT accelerated from 2.8% of GDP in 2017 to 3.2% and 3.3% in 2018 and 2019, respectively. However, direct taxes only slightly increased, given PIT decreased in the same period.

Property tax (PT) was observed to have contributed considerably less to GDP than the different direct tax categories, as depicted in Figure 3. On average, it accounted for 1.5% of GDP between 1990 and 2019. It remained comparatively stable over the years as it was not the primary target for reform as opposed to PIT and CIT and fluctuated within the range of 1.0% of GDP to 2.0%. Similarly, other forms of income tax remained steady following the abolition of levies in 1995, contributing to 1.2% of GDP on average.

Figure 3: Major Categories of Direct Taxes (% of GDP)



Sources: Accountant General, Ministry of Finance, Barbados Statistical Service, Author's Calculations

It is worth repeating as Table 1 in the Appendix indicates taxes have undergone many discretionary changes, particularly in recent years. Most notably, the marginal rates for PIT fell from 40% and 25% from 1990 to 28.5% and 12.5% in 2019, respectively, while CIT tax rates plunged from 37.5% to 5.5% in the same period. This contrasts the VAT rate which has remained rather steady, having only undergone one change (15% to 17.5%).

This overview has shown that total tax revenue has fluctuated from 1990 to 2019, although not in a fully linear pattern but rather in a sawtooth form. Indirect taxes as a percentage of GDP tended to be volatile while direct taxes were relatively stable compared to indirect taxes, despite being the focus of major tax reforms over the years. It is therefore fair to say that the Barbados tax system has experienced different degrees of efficiency and effectiveness during the period of interest.

3. Literature Review

There is considerable literature on the responsiveness of tax revenue to GDP in a diverse set of countries. Precisely, this literature review aims to examine key contributions made toward the topics of tax buoyancy and elasticity from both a theoretical and empirical point of view. This examination will enable us, among others, to develop a suitable model and econometric techniques to estimate buoyancy and elasticity for Barbados. Ordinary Least Squares (OLS), Vector Autoregressive (VAR) process, Johansen Cointegration Process and Autoregressive Distributed Lag (ARDL) combined with Error Correction Model (ECM) are the econometric techniques often used to obtain the buoyancy estimates. The Proportional Adjustment (PA) method, The Divisia Index (DI) Technique, the Constant Rate Structure Method (CRSM), and the Dummy Variables are techniques used in conjunction with the previous techniques to estimate tax elasticities.

3.1. Theoretical Considerations

Economic literature shows that there is a consensus regarding the definitions and theoretical implications of tax elasticity and buoyancy. Early work by Leuthold and N'Guessan (1986) briefly states that tax buoyancy is used to measure the responsiveness of tax revenue to GDP. Tax buoyancy is a raw assessment that reflects both discretionary and automatic growth of revenue. Here, discretionary growth of revenue captures the growth in tax revenue associated with changes in tax laws whereas automatic growth of revenue describes the growth in tax revenue caused by growth from in GDP void of the effect of discretionary tax laws changes. Formally, buoyancy can be written as:

$$TB = \frac{\%\Delta TR}{\%\Delta Y}$$

where TB represents tax buoyancy, ΔTR is the change in Total Tax Revenue and ΔY is the change in the tax base, GDP (Scott-Joseph et al., 2016).

Similar to buoyancy, elasticity measures the responsiveness of tax revenue to GDP. However, it excludes the discretionary growth of revenue (Deli et al., 2018; Leuthold and N'Guessan, 1986; Roberts et al., 2018). This is known as the automatic growth potential of the tax system as we assume that tax laws are held constant by the fiscal authority. Essentially, the tax revenue series must be adjusted for any legislative and administrative changes to tax laws (Koester and Preismeier, 2017). Measuring these discretionary changes is important as it helps clarify whether revenue growth is driven endogenously by the development of the tax base or exogenously by policy-induced measures. However, acquiring information on discretionary changes is often difficult. Accurate information may be unavailable, and if available, may result in a large loss of degrees of freedom, especially in developing countries with relatively short time series (Leuthold and N'Guessan, 1986). Tax elasticity can be represented by the following:

$$TE = \frac{\%\Delta ATR}{\%\Delta Y}$$

where TE represents tax elasticity, $\%\Delta ATR$ represents tax revenue growth where the effects of discretionary changes to policy have been adjusted for and $\%\Delta Y$ is GDP growth.

Skeete et al. (2003), and later Mourre and Princen (2015), contribute to the theoretical literature by explaining the significance of the tax buoyancy and elasticity estimates. The unanimity is that an elasticity estimate of one is considered unit elastic and indicates that a one percentage point increase in income would leave the tax-to-GDP ratio unchanged. An estimate greater than one is viewed as elastic and would increase tax revenue by more than GDP and is considered elastic. Finally, an estimate of less than one is considered inelastic and would increase tax revenue by less than GDP. This criterion is also applied to tax buoyancy where the effectiveness of discretionary changes is incorporated. Given this, we presume that a higher elasticity and buoyancy coefficient is a desirable characteristic of a tax system. This feature suggests that the tax system is adequately collecting tax revenue from its respective tax base with minimal losses.

It is important to highlight the relevance of differentiating buoyancy and elasticity, by duration (Khadan, 2020). This gives insight into how the tax system transitions from the short run to the long run as GDP changes and is a form of surveillance over tax revenue. Short-run buoyancies are geared towards the stabilisation aspect of fiscal policy, whereas long-run buoyancies impact long-term fiscal sustainability concerns. In theory, a tax system that faces minimal losses in collecting its tax (i.e., an effective tax system) will be elastic in both the short and long run, signalling its ability to automatically stabilise the economy while improving the fiscal balance through economic growth.

To estimate the responsiveness of the tax system, three tax bases are commonly used. The majority of the literature utilises GDP as the tax base as it has the advantage of different tax categories to be compared under the same tax base. However, other studies measure responsiveness relative to a macroeconomic base. Examples of this include using private consumption as a proxy for VAT or the total wage bill as a proxy for PIT. These tax bases tend to act as a more appropriate tax base. However, it does not allow for comparison across the different tax categories. Lastly, responsiveness is measured relative to the output gap, which essentially captures tax revenue changes due to a 1% output gap (Deli et al., 2018).

3.2. Empirical Review

Most of the previous studies have quantified the sensitivity of tax revenues to GDP by regressing tax revenue on GDP and other appropriate bases using a time series configuration of data. A time series is useful when studying a single country for a period with many intervals.

For instance, Mansfield (1972) examined the tax system of Paraguay for the period 1962–1970 through tax buoyancy and elasticity estimates using annual data. The tax buoyancy estimate was obtained by an ordinary least-squares (OLS) regression of logged tax revenue on logged GDP. Elasticity was estimated by developing tax revenue series and separating discretionary changes using the Proportional Adjustment (PA) method, a method introduced by Prest (1962). An argument for the use of the PA method was that the period in focus was an era of conscious tax reform, making the Dummy Variable technique ineffective (Bilquees 2004). The buoyancy and elasticity estimates were 1.69 and 1.14, respectively, suggesting that the tax system was satisfactory. Tax revenues were further divided into categories such as income tax, import tax, excise tax, etc. The elasticities of these categories were compared on a base-to-income and tax-to-base basis. He concluded that the significant rise in tax ratio was mainly attributed to the discretionary changes to the tax system, particularly through raising indirect taxes and adopting a new sales tax on imported goods.

Choudhry (1979) measured the elasticity of tax revenue to GDP using the period 1955 to 1975 for Kenya, Malaysia, the UK, and the USA. Like Mansfield (1972), the OLS regression was used to calculate elasticity. The Divisia Index (DI) approach was of interest to measure the effects of discretionary changes instead of the PA method. He pointed out that the PA method is the preferable method given its capacity to unbiasedly handle tax reforms when reliable information about discretionary changes is available. However, this approach is limited when information is unavailable, making the DI method the preferable option in those circumstances. The findings showed the buoyancies for the US, the UK, Malaysia, and Kenya reached 1.04, 1.18, 1.70, and 1.42, respectively. The elasticities were evaluated at 1.04, 1.24, 1.57, and 1.32, correspondingly. These estimates suggest that the tax systems of the four countries were buoyant and elastic, signalling a progressive relationship between economic growth and tax revenue.

Bilquees (2004) used a Vector Auto-Regressive (VAR) model to investigate the elasticity and buoyancy of the tax system in Pakistan between 1974 and 2003 using annual data. In terms of elasticity, he exploited the Divisia Index technique[8] developed by Choudhry (1979) to clean the tax revenue series of discretionary changes. Unlike Mansfield (1972) and Choudhry (1979), this study distinguished the long-run estimates from the short-run estimates owing to the cointegration framework. The results obtained are as follows: the buoyancy estimate reached 0.92 in the long run and 0.44 in the short run, while the elasticity estimate was 0.88 and 0.33 in the long run and short run, respectively. He concluded that these lacklustre estimates were mainly caused by the reduction of trade tariff rates over time, causing customs duties to be the least responsive to changes in income.

In Barbados Skeete et al. (2003), using an error correction model, found that the buoyancy of the tax system was adequate in both the long run and short run (1.32 and 1.11, respectively) while being elastic in the short-run (1.07) but slightly inelastic in the long run (0.93). Notably, to net out the effect of discretionary changes to the tax revenue series, the Proportional Adjustment (PA) method by Prest (1962) was used. This method makes use of budget estimates of the effects of discretionary changes and subtracts them from the tax revenue series. This approach to estimating buoyancy and elasticity closely followed Mansfield (1972) although the latter did not use ECM. Scott-Joseph et al. (2016), among others, derive the short-run and long-run estimates of tax buoyancy for Barbados in the period 1980-2014 using the error correction model approach. The results show the lack of buoyancy in all categories of taxes in the short run while in the long run buoyancy is uncovered in Income Tax, Value-Added Tax (VAT), and Company Tax.

Wolswijk (2007) calculated the long-run and short-run elasticities of the Netherlands using annual country data. Contrary to Skeete et al. (2003), a single logarithm regression is specified, with tax revenue being dependent on the tax base. Private consumption was used as the tax base for the individual indirect tax categories, wages for government and business employees were used for PIT and the net exploitation income of the private sector captures the tax base for CIT. Apart from the OLS estimates,

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[8] Bilquees (2004) argues in favor of the Divisia Index technique, adding that despite the accuracy of the CRSM, it is the most data intensive way of extracting the effects of discretionary changes from tax revenue time series.

the Dynamic Ordinary Least Squares (DOLS) estimates of the long-run buoyancy were also provided as it has superior properties in comparison to OLS. Like Skeete et al. (2003) and Mansfield (1972), Wolswijk (2007) employed the PA method to eliminate discretionary changes from the tax revenue series. Although data on discretionary changes were made available by the Dutch Ministry of Finance, Wolswijk (2007) highlighted two limitations of this approach. Firstly, endogenous responses between tax categories are usually excluded from the model and secondly, emphasis on revenue changes in the initial year may lead to only a part of the total change being explored.

Yousuf and Huq (2013) estimated the elasticity and buoyancy of major tax categories for Bangladesh and their policy implications. In the context of Johansen cointegration model, while buoyancy is simply obtained as the derivative of log tax with respect to log base, for elasticity two steps are involved: (a) removing the effects of discretionary changes from the actual tax yields using an exponential smoothing technique and (b) regressing the adjusted tax series on the tax base and including some dummy variables. The key findings are that Income Tax, Sales Tax, and VAT are elastic and buoyant to their respective base while Import Duty is essentially inelastic.

Unlike the majority of the papers in tax elasticity literature that use annual data, Havranek et al. (2015) make use of quarterly data (taxes and tax base) in their analysis of elasticity in the Czech Republic. They posited that this was necessary as the annual data series available were too short for meaningful regression analysis. The authors used an error correction model of the relationship between tax and some tax base to obtain short-run estimates and the dynamic OLS (DOLS) to generate long-run estimates. They highlighted a problem with using quarterly data is that both tax revenue and tax bases are subject to a high degree of seasonality. Unlike the previous literature, this study utilised a dummy variable to account for the major tax reform in the Czech Republic. In the long run, they found the buoyancy of wage tax, VAT, profit tax, and social security to be 1.445, 0.867, 1.687, and 1.016 respectively, while in the short run they were estimated to be 0.316, 0.453, 0.587, and 1.189, respectively.

Deli et al. (2018) conducted a study of the buoyancy of various tax revenues using panel data. This study entailed a group of 25 OECD countries for the period 1995 to 2015. They applied an Autoregressive Distributive Lag Model (ARDL) where logged tax revenue is regressed on a lag of itself and logged GDP as the tax base. To find the average buoyancy, the Mean Group (MG) method by Pesaran and Smith (1995) and the Pooled-Mean Group (PMG) method by Pesaran et al. (1999) were employed. Deli et al. (2018) highlighted that the MG estimator for buoyancy allows for a large degree of heterogeneity as both the intercept and the buoyancies are allowed to vary across nations in the short and long run. However, the PMG estimator restricts long-run heterogeneity and suggests that long-run intercepts and buoyancies are equal across countries. Similar to Havranek et al. (2015), the short-run buoyancy is estimated using the OLS while the long-run buoyancy is estimated using the DOLS.

Khadan (2020) closely followed Deli et al. (2018) in methodology using the ARDL-ECM technique to investigate the buoyancy for a group of 12 Caribbean countries over the period 1991 to 2017. However, it differs in that it tests for stationarity and cross-sectional independence among panel units, using the Pesaran (2007) and Pesaran (2004) tests respectively. The outcomes of the test suggest that there was evidence of cross-sectional dependence among variables while being integrated in the order of I (1). Cointegration was then tested for using the Westerlund test which deemed there was strong evidence of cointegration between real GDP and each tax category. The study compared pre-crisis and post-crisis buoyancy levels following the 2008 Global Crisis. The findings displayed that PMG's long-run buoyancy before and after 2008 were 1.552 and 0.631, respectively, while the short-run buoyancy was 0.921 and 1.439, respectively. This suggests that although the tax system became very stable post-crisis in the short run, the government must avoid expenditure that does not contribute to structural expansion if it wants to achieve its goal of a positive fiscal balance.

Naape and Mahonye (2020) performed several tests to calculate the buoyancy of the South African tax system using the ARDL model. The results showed that tax revenue (0.82), VAT (0.69), and customs duties (-0.41) were nonbuoyant in the short run. VAT was buoyant in the long run, while Total Tax Revenue was nonbuoyant in the long run. For note, the tests showed an absence of cointegration for customs duties.

To recall, the objective of this section was to examine the literature dealing with the generation of estimates of tax buoyancy and elasticity. The overview of the literature indicates that while there is no issue concerning the meaning of the concepts of interest, how to obtain empirically reliable estimates of buoyancy and elasticity is an issue, particularly for "elasticity." For most time-series studies, the ARDL-ECM methodology dominates other methodologies, yet its parameter estimates are affected by the size of the time series despite the contrary claim and the uniqueness of cointegrated relationships imposed by the method does not always hold rendering the parameter estimates inconsistent. In addition, drawing cointegration conclusions based on asymptotic critical values derived by Pesaran et al. (2001) can be misleading since these values can be different from the finite sample values (see Narayan, 2005). Concerning elasticity estimates per se, implementation of the methods used to capture tax law changes so far is dependent on the data availability and wealth of information. In fact, what is lacking is a comparative study of different methods for elasticity estimation. In terms of our paper, we pay more attention to the issue of generating elasticity estimates through a double exponential smoothing rather than one simple exponential smoothing found in the literature, as well as a single dummy to capture multiple tax law changes. These methods are good alternatives to the methods encountered in the literature. More importantly, our paper can be seen as an upgrade of Skeete et al. (2003), the unique study on Barbados.

4. Methodology

4.1. Data Sources

The annual time series data for this study cover the period 1990 to 2019 and include the revenues of various taxes and nominal GDP. Nominal GDP is generally preferred to real GDP as it encompasses inflationary forces. The annual data on tax revenue is retrieved from the Barbados Treasury Department of the Ministry of Finance and Economic Affairs (Accountant General, Personal Communication, June n.d., 2021), while the annual nominal GDP is taken from the Barbados Statistical Service. The various tax revenues are mentioned in the overview in Section 2. The discretionary changes (see Table 1 in Appendix) are sourced from the relevant acts issued by the Government of Barbados. Note that the main features of the data were presented in the Overview section.

4.2. Model

As time-series of a certain length are involved, it is useful in the first instance to raise the issue of stationarity/non-stationarity of univariate variables as this can affect the validity of the method of estimation of parameters[9]. For note, a stationary series is integrated of order zero or I(0). A nonstationary series is also known as an integrated series. If it must be differenced once to become stationary, then it is I(1). We use the Augmented Dickey-Fuller (1979) unit root test or ADF test to decide on the non-stationarity or stationarity of a univariate series. Being considered common knowledge, the test is not explained here.

In terms of the model to capture the causal relationship between some tax variables and tax base (GDP here), we recourse to the autoregressive distributed lag (ARDL) model validated through the ARDL Bounds Test (Pesaran, 1997; Pesaran et al., 2001). The latter is useful as it tests for cointegration among the variables even with a mixture of I (0) and I (1) variables and a small sample.

Following the literature, we posit the following long-run model:

$$\ln TR_t = \alpha_0 + \beta_0 \ln GDP_t + \varepsilon_t \tag{1}$$

where ln stands for logarithm, where TR_t denotes the tax revenue category of interest at time t, GDP_t denotes the nominal GDP at time t or any other tax base at time t, α_0 denotes a constant term, and ε_t is the error term at time t.

In any case, closely following the works of Deli et al. (2018) and Khadan (2020), we can transform Equation 1 into the following general Autoregressive Distributive Lag Model, ARDL (p, q):

$$\ln TR_t = \alpha_0 + \sum_{j=1}^{p} \delta_j \ln TR_{t-j} + \sum_{j=0}^{q} \beta_j \ln GDP_{t-j} + \varepsilon_t \tag{2}$$

where variables are defined as above. Note that TR_t might change when estimating elasticity.

The choice of optimal lag lengths for the dependent and independent variables p and q, respectively, is arrived at using some information criterion (i.e., the Akaike Information Criterion (AIC); the Schwarz Information Criterion (SIC)).

Rearranging Equation 2 (see Deli et al. 2018) yields the following Error Correction Model (ECM):

$$\Delta \ln TR_t = \alpha_0 + \sum_{j=1}^{p} \gamma_j \Delta \ln TR_{t-j} + \sum_{j=0}^{q} \theta_j \Delta \ln GDP_{t-j} + \lambda ECT_{t-1} + \varepsilon_t \tag{3}$$

In this model specification, λ measures the speed of adjustment in the equation; that is, the rate at which the variables converge to their long-run equilibrium. θ_0 measures the short-run estimate (buoyancy or elasticity), and β_0 is the corresponding long-run estimate. To λ is associated ECT_{t-1} (lagged error or equilibrium correcting term). It is in fact the lagged error-correcting term (ε_{t-1}) or the lagged implicit form of Equation 1. Following the short-run estimation, the long-run relationship is determined, i.e., the model is tested for cointegration. The null hypothesis of no cointegration between or among lagged

[9] "Stationarity is an important concept in econometrics for at least three reasons. First, most tests statistics have been derided under the assumption of stationarity. Second, in some circumstances the lack of stationarity gives rise to nonsense results (e.g., nonsense or spurious regressions). Third, according to Wold's theorem any stationary series can be decomposed in two parts: a deterministic part and a nondeterministic part (a moving average of infinite order)." (Mamingi 2005, p. 160).

level variables is set against the alternative hypothesis of cointegration. At a given level of significance, an F-statistic (called Cointegration F-statistic by us) of more than the upper bound critical F-value at I (1) suggests that the null be rejected and an F-statistic of less than the lower bound critical F-value at I (0) indicates that the null is not rejected. If the F-statistic lies between the two critical F- values, then the test is considered inconclusive. Note that Pesaran et al. (2001)'s asymptotic critical values for cointegration F can be inaccurate with small samples. Narayan (2005) derived the critical values for finite samples. In any case, the bounds F-test results must be supported by those of the t-statistics of the speed of adjustment. For more details, see Pesaran et al. (2001). At a given level of significance, if the t-statistic of the speed of adjustment is negative and, in absolute value, greater than the upper bound critical t-value (at I (1)), then cointegration is uncovered. If the t-statistic of the speed of adjustment is negative and, in absolute value, lesser than the lower bound critical t-value (at I (0)), then cointegration is not present. When the t-statistic is negative and, in absolute value, lies between the absolute values of t-bounds at I (1) and I (0), then cointegration is inconclusive.

For the validity of the model, the misspecification or diagnostic tests must be conducted and passed. These are the Breusch-Godfrey Serial Correlation LM test, the Breusch-Pagan-Godfrey Heteroscedasticity test, the Ramsey Reset test, and the Jarque-Bera Normality test. Note that if the sample is not large enough, then the F versions of those LM tests are of interest.

True, the ARDL imposes a single unique cointegrating relationship, but this is not an issue in the context of a bivariate relationship since here one can only have one cointegrated relationship. Thus, the potential endogeneity of GDP is not an issue. For more than two variables, there is a possibility of more than one cointegrating relationship and here endogeneity of GDP may become an issue.

Although the ARDL, our core methodology, is applied to the estimation of buoyancy without any major changes, the estimation of elasticity, on the contrary, requires some transformation of the variables or the judicious use of dummy variables. In other words, to obtain our elasticity, here we recourse to two approaches. The first approach concerns the removal of discretionary tax changes effects using the double exponential smoothing approach and the second approach is the judicious use of dummy variables, similar to Wanjala (2019). These approaches are not necessarily superior to the other approaches alluded to in the literature (i.e., the PA approach, the Divisia Index (DI) method, and the Constant Rate Structure Method (CRSM)). The chosen methods are based on the availability of appropriate data to apply the techniques.

4.2.1 Double Exponential Smoothing

A time series consists of a trend, a seasonal component, a cyclical component, and a random component. In our circumstances, we want to eliminate the random component to focus on the main components. It is the case that in our view, the discretionary tax changes can be assimilated to a random variation. One method of eliminating random variation is the exponential smoothing technique.

$$S_t = \alpha Y_t + (1 - \alpha) S_{t-1} \tag{4}$$

where S_t is the single smoothed series, Y_t is the series to be smoothed (here, the tax variable) and α is the smoothing factor ($0 < \alpha \leq 1$). The presence of linear trends in the series triggers the need to smooth the smoothed series. This gives rise to the double exponential smoothing.

$$D_t = \alpha S_t + (1-\alpha) D_{t-1} \tag{5}$$

where D_t captures the second phase of smoothing.

The cleaned tax series in logged form is obtained through equation 5. Thereafter, we use this new tax series in our core regression (3) to derive our short-run and long-run elasticity(ies). As a note, autocorrelation induced by exponential smoothing is generally an empirical matter. If there is one, then an autoregressive process (i.e., AR (1)) correction can be applied.

4.2.2 Dummy Variable Approach

Here, we use the information on discretionary tax changes (see Table 1 in Appendix) through policy implemented by the Government of Barbados. We capture those changes by a dummy variable with 1 if the event occurred and 0 if not. Like Yousuf and Huq (2013), we use a single dummy contrary to multiple dummies so pervasive in the literature. By doing so the issue of using up the degrees of freedom is eliminated. Unlike Yousuf and Huq (2013) no transformation is made to the dummy to capture tax law changes.

The original model 1 becomes

$$\ln TR_t = \alpha_0 + \beta_0 \ln GDP_t + \gamma D_t + \rho D_t \ln GDP_t + \varepsilon_t \tag{6}$$

where D is the dummy variable described as above and other variables are defined as above.

It is worth noting that contrary to Yousuf and Huq (2013) and most econometricians, our Equation 6 respects the principle of marginality; that is, aside from the interactive effect, the main effect (variable) is present. Equation 6 itself is part of a new ECM, that is, Equation 3 with dummies.

As an illustration, the tax elasticity with respect to GDP in the context of Equation 6 is given by:

$$\frac{\partial \ln TR_t}{\partial \ln GDP_t} = \beta_0 + \rho \bar{D} \tag{7}$$

with $\bar{D}$ being the “mean” of the dummy variable. Note that statistical significance matters.

5. Results

5.1 Unit Root Test

Table 2 provides the results of the ADF test applied to check for stationarity. At the levels, the series are all nonstationary as indicated by the sizes of the P-values compared to the 10% level of significance. On the contrary, the P-values of the first differences show that the different series are all stationary. That is, the original series are all I (1).

Table 2: Unit Root Status of Variables

Variables	Level		First difference	
	t-stat	P-value	t-stat	P-value
LNGDP	-1.439	(0.549)	-3.189	(0.031) *
LNTR	-1.151	(0.682)	-5.496	(0.000) *
LNDT	-1.174	(0.670)	-5.915	(0.000) *
LNIT	-1.967	(0.596)	-5.445	(0.000) *

Note: * Denotes significance at 10%. GDP: Gross Domestic Product; TR: Total Tax Revenue; DT: Direct Taxes; IT: Indirect Taxes; LN: Logarithm

5.2 Evaluating the Buoyancy Estimates

Since all variables are I(1), we can, among others, use the ARDL framework for modelling and testing for cointegration. Table 3 provides the results of the estimation of the ARDL-ECM of Equation 3 for Total Tax Revenue. In the first instance, the results of the diagnostic tests suggest that the model passes the tests for serial correlation, heteroscedasticity, and specification errors. The P-value of the Jarque-Bera test implies that the residuals are normally distributed about the mean. In terms of cointegration, the sizes of our Cointegration F-statistic (9.888) and our t-statistic from our speed of adjustment (-4.532) compared to the respective critical values of the Bounds tests[10] (see note to Table 3) indicate that there is cointegration between Total Tax Revenue and GDP. The speed of adjustment (-0.768) is statistically significant and shows that buoyancy converges to its long-run buoyancy at a rate of 76.8% per year. The short-run buoyancy is below one (0.822), whereas the long-run buoyancy is above one (1.070). Similarly, Bilquees (2004) found Total Tax Revenue in Pakistan has low buoyancy (0.44) in the short run. However, the long-run estimate obtained also showed low buoyancy (0.92). Skeete et al. (2003) found that the Barbados tax system was buoyant for Total Tax Revenue in the short run (1.11) and long run (1.32) in the period 1977-1999. Scott-Joseph et al. (2016) among others found in the period 1980-2014 the Barbados Tax System lacks buoyancy in the short run for Total Tax Revenue and exhibits buoyancy in the long run. As can be seen, for Barbados our buoyancy results for total tax revenue concur with those of Scott-Joseph et al. (2016).

[10] Narayan (2005)'s critical values for n=30 are with k=1, 4.290 for I(0) and 5.080 for I(1) and with k=3, 3.008 for I(0) and 4.150 for I(1).

Table 3: ARDL (1,0) of Logged Total Tax Revenue, Barbados 1990-2019

Variable	Coefficient	Std. Error	t-Statistic	Prob
D(LNGDP)	0.822	0.196	4.110	0.000
CointEq (-1)	-0.768	0.169	-4.532	0.000
LNGDP	1.070	0.041	26.177	0.000
C	-2.019	0.365	-5.528	0.000
R-squared	0.979		Mean dependent var	7.462
F-statistic	608.712		Akaike info criterion	-2.923
Prob (F-statistic)	0.000		Schwarz criterion	-2.781
SCF (2,24) =1.731	P=0.199		Hannan-Quinn criter.	-2.878
HF (2.26) =0.464	P=0.634		MF (1,25) =1.585	P=0.220
JB=0.114	P=0.945		CF=9.888	k=1
ARDL (1,0)				

Note: All variables are logged. Equation 3 is of interest. The regressand is Total Tax Revenue and the regressors are lags of Total Tax Revenue and nominal GDP. SCF denotes the Breusch-Godfrey F test for serial correlation. CointEq (-1): lagged ECT. HF denotes the Breusch-Pagan-Godfrey F test for heteroscedasticity, JB denotes the Jarque-Bera test for normality, MF is the Ramsey Reset test for error specification. CF denotes the cointegration F-statistic. P or Prob denotes the probability value of the associated statistic. The tests are conducted at a significance level of 10%. For k=1 with k being the number of explanatory variables in the long-run relationship, the critical values for tests for cointegration are for CF: F-lower bound=4.04 and F-upper bound=4.78 while for t-bound test for cointegration, the critical values are t-lower bound=-2.57 and t-upper Bound=-2.91.

Table 2 in the Appendix shows that the ARDL model for Direct Taxes passes the various diagnostic tests given each P-value is greater than the significance level. There exists cointegration as the Cointegration F-statistic (6.811) surpasses the upper value bound, with the t-statistic of the speed of adjustment further confirming this observation. The speed of adjustment (-0.755) is statistically significant. Similar to Total Tax Revenue, the short-run buoyancy was estimated to be below one (0.509) and the long-run buoyancy above one (1.047).[11] Contrarily, Howard (1989) uncovered a different pattern in the period 1974-1984 in Barbados, with a low tax buoyancy in the long run (0.85).

Concerning the validity of the model for Indirect Taxes in Table 3 in the Appendix, the Jarque-Bera test suggests that the residuals are not normally distributed as indicated by the size of the P-value. The model passes, however, all other diagnostic tests as indicated by the P-values. The Cointegration F-statistic (4.889) combined with the t-statistic (-3.189) imply that there exists cointegration between Indirect Taxes and GDP. The speed of adjustment reached -0.598 and was statistically significant. The short-run and long-run buoyancies are estimated to be 1.404 and 1.141, respectively. Skeete et al. (2003) also revealed that the buoyancy of indirect taxes in Barbados in the period 1977 to 2003 has been above one in both the short run and the long run (1.22 and 1.54, respectively), highlighting the stability of this category over the years.

[11] The lack of significance of many lagged variables is probably due to multicollinearity and not necessary (mis)specification. This is also the case in Table 4 of the Appendix.

5.3 Evaluating the Elasticity Estimates

5.3.1 The Double Exponential Smoothing Approach

In the first instance, we use the double exponential smoothing approach to clean up tax series, precisely to get rid of the impact of discretionary tax changes. The results of the estimation of Equation 3 with double exponential smoothed tax variables as dependent variables are given in Table 4 below as well Tables 4 and 5 in the Appendix.

The three regressions (Total Tax Revenue, Direct Taxes, and Indirect Taxes) pass all the diagnostic tests; cointegration is uncovered for the Total Tax Revenue equation as well as Indirect Taxes equation. The behavior of Direct Taxes needs some explaining. Indeed, the size of Cointegration F-statistic for Direct Taxes (4.183) which lies between the lower bound critical F-value (4.04) and the upper bound critical F-value (4.78) suggests cointegration is inconclusive[12.] Nevertheless, the speed of adjustment t-statistic (-2.968) being in absolute value greater than the upper bound critical t-value (2.91 in absolute value) (see note to Table 3) confirms the existence of cointegration between Total Tax Revenue and Indirect Taxes with GDP.

[12] This is not the case using Narayan (2005)'s critical values (see footnote 10).

Table 4: ARDL (4,0) of Double Exponential Smoothed Logged Total Tax Revenue (LNTRSM)

Variable	Coefficient	Std.Error	t-Statistic	Prob
D (LNTRSM (-1))	0.315	0.141	2.232	0.037
D (LNTRSM (-2))	0.212	0.160	1.322	0.201
D (LNTRSM (-3))	0.332	0.171	1.943	0.066
D(LNGDP)	0.823	0.168	4.898	0.000
CointEq (-1)	-0.729	0.134	-5.445	0.000
LNGDP	1.129	0.056	20.040	0.000
C	-2.575	0.507	-5.075	0.000
R-squared	0.977		Mean dependent var	7.531
F-statistic	167.453		Akaike info criterion	-2.836
Prob (F-statistic)	0.000		Schwarz criterion	-2.546
SCF (2,18) =0.372	P=0.694		Hannan-Quinn crit.	-2.752
HF (5,20) =0.542	P=0.742		MF (1,19) =1.168	P=0.293
JB=0.700	P=0.705		CF=8.975	k=1
ARDL (4,0)				

Note: Equation 3 is of interest with double exponentially smoothed logged Total Tax Revenue (where LN stands for natural logarithm). See Note to Table 3 for the meaning of test symbols and critical values for cointegration.

In the period 1990-2019, the Barbados Tax system is not elastic in the short run for Total Tax Revenue (0.823), Direct Tax (0.349), and Indirect Tax (0.548) and on the contrary, elastic in the long run for Total Tax Revenue (1.129) and Indirect Tax (1.130). Skeete et al. (2003) found that in the period 1977-2003 the Barbados Tax System was elastic in the short-run (1.07) but slightly inelastic in the long run (0.93). Bilquees (2004) found that the Pakistan Tax System was inelastic in the short run (0.33) and long run (0.88).

5.3.2 The Single Dummy Variable Approach

Table 5 presents the results of the ARDL-ECM for Total Tax Revenue using a dummy variable to capture discretionary tax changes. The regression passes all the diagnostic tests of interest as implied by the sizes of their respective P-values. Cointegration holds as Cointegration F-statistic (7.319) is greater than the upper-value bound = 3.77 (4.150 for Narayan) at the 10% level13. The speed of adjustment is fast: 84.3% of disequilibrium eliminated in one year. The short-run and long-run elasticities are 0.749 and 0.889, respectively computed as in Equation 7. Bilquees (2004) used a Divisia index and a cointegration approach for the Pakistan Tax System in the period 1974-2003 and found a short-run elasticity of 0.33 and a long-run elasticity of 0.88. Skeete et al. (2003) alluded to prior found for the Barbados Tax System a short-run and long-run elasticity of 1.07 and 0.93, respectively.

[13] Results were taken from the student version of EViews 11. Discrepancies were noted in the Single Dummy Variable Approach when compared to EViews 9 as different standard errors were computed for the speed of adjustment.

Table 5: ARDL (1,0,1,1) Cointegrating and Long-Run Form for Logged Total Tax Revenue with Dummy (DU_TR)

Variable	Coefficient	Std. Error	t-Statistic	Prob
D(LNGDP)	0.749	0.208	3.608	0.002
D(DU_TR)	-0.850	0.585	-1.455	0.160
D(DU_TRxLNGDP)	0.095	0.066	1.439	0.164
CointEq (-1)	-0.843	0.146	-5.768	0.000
LNGDP	0.889	0.078	11.430	0.000
DU_TR	-2.406	0.875	-2.749	0.012
DU_TRxLNGDP	0.274	0.098	2.784	0.011
C	-0.408	0.698	-0.584	0.565
R-squared	0.986		Mean dependent var	7.462
F-statistic	255.023		Akaike info criterion	-3.036
Prob (F-statistic)	0.000		Schwarz criterion	-2.706
SCF (2,20) =1.087	P=0.356		Hannan-Quinn crit.	-2.932
HF (6,22) =0.906	P=0.508		MF (1,21) =2.746	P=0.112
JB=1.813	P=0.404		CF=7.319	k=3
ARDL (1,0,1,1)				

Note: Equation 3 is of interest with DU_TR, a dummy capturing discretionary tax changes in Total Tax Revenue (1 if an event occurs and 0 otherwise) and LN stands for natural logarithm. For other details, see note to Table 3. For k=3 with k being the number of explanatory variables in the long-run relationship, at the 10% level of significance, the critical values for tests for cointegration are for CF: F-lower bound=2.72 (3.008 for Narayan) and F-upper bound=3.77 (4.150 for Narayan) while for t-bound test for cointegration: t-lower bound =-2.57 and t-upper bound=-3.46.

Table 6 in the Appendix presents the results of the ARDL-ECM for Direct Taxes using dummy variables to capture discretionary tax changes. The regression passes all the diagnostic tests of interest as implied by the sizes of their respective P-values. Cointegration exists as F-statistic is greater than the I(1) bound=3.77 at the 10% level. The speed of adjustment is fast: 81.9% of disequilibrium eliminated in one year. The short-run and long-run elasticities are -0.069 and 0.915, respectively. Yousuf and Huq (2013) uncovered high elasticity estimates for long-run Direct Taxes for Bangladesh in the 1980-2011 period.

Table 7 in the Appendix deals with the results of the ARDL-ECM with a dummy variable to capture discretionary taxes changes around Indirect Taxes. The model passes all the diagnostic tests of interest. The Cointegration F-statistic (4.612) and t-statistic (-4.606) indicate cointegration. Indirect Taxes are highly elastic in the short run (1.452) and the long run (1.116).

Table 6 puts together all the results for buoyancy and elasticity.

Table 6: Summary Results: Tax Buoyancy and Elasticity for the Barbados Tax System, 1990-2019

	Buoyancy	Elasticity (DES)	Elasticity (Dummy)
Total Tax Revenue			
Short-run	0.822 (NB)	0.822 (IE)	0.806 (IE)
Long run	1.070 (B)	1.129 (E)	1.053 (E)
Direct Taxes			
Short run	0.509 (NB)	0.349 (IE)	-0.229 (IE)
Long run	1.047 (B)	1.043 (E)	0.867 (IE)
Indirect Taxes			
Short run	1.404 (B)	0.548 (IE)	1.499 (E)
Long run	1.141 (B)	1.130 (E)	1.178(E)

Note: results from various tables; DES: Elasticity from ARDL-ECM using Double Exponential Smoothing Tax; Dummy: Elasticity from ARDL-ECM using dummy variables; B=Buoyant; NB: Non-Buoyant; IE: Inelastic; E: Elastic.

6. Policy Implications and Conclusion

This paper estimates the sizes of the buoyancies and elasticities of the tax system in Barbados in the period 1990 to 2019. It accomplishes this by utilising the ARDL model to derive each estimate while making use of two methods to extricate the effects of tax reform on revenue: the Double Exponential Smoothing Approach and the Single Dummy Variable Approach. Results indicate that the total tax revenue is nonbuoyant in the short run but buoyant in the long run. The short-run outcome is attributed to the underperformance of direct taxes while indirect taxes performance was buoyant, greatly outperforming its counterpart. Concerning the long run, direct and indirect taxes behaviours affect the buoyancy for total tax revenue, as both were buoyant. Additionally, the overall tax structure displays high levels of elasticity. Similarly, indirect taxes outpace direct taxes in both the long run and the short run with regards to elasticity, acting as the driving force of the overall structure.

As it relates to the direct tax estimates, it is clear that there must be work done to expand the buoyancy and elasticity of this category. The short-run buoyancy of direct taxes is significantly below one while the elasticity reaches below zero. Though convergence to the long-run equilibrium increases the value of these estimates, these low scores raise concerns about potential loopholes for tax evasion, particularly in the case of PIT and CIT. It may also be a symptom of a complex direct tax system that deters voluntary compliance by taxpayers. If true, this adds further strain on resources given that a larger share of the labour force must be employed to follow up on persons and businesses that were unsuccessful in paying their taxes to ensure compliance with regulations. Failure to mitigate these may impair the government's ability to fully maximise its tax collection from direct taxes. Hence, it should be a priority to assess the current direct tax regime and determine if information about tax registration is adequately circulated among the public.

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Appendix

Table 1: Discretionary Changes, Barbados, 1990-2019

Direct Taxes
Personal Income Tax
• 1993: Reform of tax brackets from six to two (40% and 25%)
• 2003: Revision of lower-income tax rate (25% to 22.5%)
• 2004: Revision of lower-income tax rate (22.5% to 20%)
• 2005: Revision of the higher-income tax rate (40% to 37.5%)
• 2006: Revision of the higher-income tax rate (37.5% to 35%)
• 2016: Reduction of tax rate (35% to 33.5%)
• 2018: Increase of tax rate (33.5% to 40%)
• 2018: Revision of tax rates (33.5% and 12.5%)
• 2019: Revision of tax rate (33.5% to 28.5%)
Corporate Income Tax
• 2003: Revision of tax rate (37.5% to 36%)
• 2004: Revision of tax rate (36% to 33%)
• 2005: Revision of tax rate (33% to 30%)
• 2006: Revision of tax rate (30% to 25%)
• 2017: Revision of tax rate (25% to 30%)
• 2018: Reform of the CIT regime to equalise rates (5.5%)
Property Tax
• 1999: New land tax rate for property sale inclusive of land (15%)
Other Direct Taxes
• 2003: Removal of various levies on payroll, health benefits, etc.
• 2015: Introduction of new bank asset tax at 0.35% per annum.
• 2015: Introduction and removal of new municipal solid waste tax
Indirect Taxes
Value-Added Tax
• 1997: Introduction of new VAT system at 15%.
• 2010: Revision of VAT tax rate to 17.5%
Excise Tax
• 1999: Reduction in excise tax on gasoline
• 2015: New Excise Tax on sugar-sweetened beverages at 10%
Other Indirect Tax
• 1990: New Consumption tax on motor vehicles
• 1992: New stabilisation tax of 1.5%
• 1994: Revision of customs tax rates and consumption tax rates
• 1995: Removal of stamp duties on agriculture and consumption tax on machinery.
• 1996: Removal of consumption tax on gas.
• 1997: Removal of 11 different categories of taxes
• 2017: NSRL introduction
• 2018: Revision of NSRL rate

Source: Various Acts Published by the Government of Barbados

Results of Buoyancy Estimation for Direct and Indirect Taxes

Table 2: ARDL (1,4) of Logged Direct Taxes, Barbados 1990-2019

Variable	Coefficient	Std. Error	t-Statistic	Prob
D(LNGDP)	0.509	0.454	1.121	0.276
D(LNGDP(-1))	0.895	0.765	1.169	0.257
D(LNGDP(-2))	-0.023	0.783	-0.029	0.774
D(LNGDP(-3))	0.153	0.711	0.214	0.833
D(LNGDP(-4))	-0.054	0.421	-1.278	0.217
CointEq(-1)	-0.755	0.199	-3.787	0.001
LNGDP	1.047	0.075	14.022	0.000
C	-	-	-	-
R-squared	0.955		Mean dependent var	6.647
F-statistic	67.586		Akaike info criterion	-2.202
Prob (F-statistic)	0.000		Schwarz criterion	-1.863
SCF(2,17)=0.297	P=0.747		Hannan-Quinn criter.	-2.104
HF(6,19)=0.286	P=0.936		MF(1,18)=1.090	P=0.310
JB=1.047	P=0.592		CF=6.811	k=1
ARDL(1,4)				

Note: Equation 3 is of interest. Regressand: LNDT, Regressor: LNGDP (where LN stands for natural logarithm). For other details, see Note to Table 3.

Table 3: ARDL(1,1) of Logged Indirect Taxes, Barbados 1990-2019

Variable	Coefficient	Std. Error	t-Statistic	Prob
D(LNGDP)	1.404	0.341	4.115	0.000
D(LNGDP(-1))	-0.721	0.308	-2.345	0.027
CointEq(-1)	-0.598	0.187	-3.189	0.004
LNGDP	1.141	0.061	18.125	0.000
C	-	-	-	-
R-squared	0.975		Mean dependent var	6.920
F-statistic	323.656		Akaike info criterion	-2.535
Prob (F-statistic)	0.000		Schwarz criterion	-2.347
SCF(2,23)=0.056	P=0.946		Hannan-Quinn criter.	-2.476
HF(3,25)=0.754	P=0.530		MF(1,24)=0.074	P=0.788
JB=20.228	P=0.000		CF=4.889	k=1
ARDL(1,1)				

Note: Equation 3 is of interest. Regressand: LNIT, Regressor: LNGDP (where LN stands for natural logarithm). For other details, see Note to Table 3.

Results of Elasticities for Double Exponentially Smoothed Direct and Indirect Taxes

Table 4: ARDL (1,4) of Double Exponential Smoothed Logged Direct Taxes (LNDTSM)

Variable	Coefficient	Std.Error	t-Statistic	Prob
D(LNGDP)	0.349	0.447	0.781	0.445
D(LNGDP(-1))	-0.067	0.762	-0.089	0.930
D(LNGDP(-2))	0.864	0.757	1.141	0.268
D(LNGDP(-3))	0.053	0.737	0.071	0.944
D(LNGDP(-4))	-0.795	0.397	-2.005	0.059
CointEq(-1)	-0.385	0.130	-2.968	0.008
LNGDP	1.043	0.151	6.902	0.000
C	6.959	10.862	0.641	0.529
R-squared	0.958		Mean dependent var	6.643
F-statistic	72.618		Akaike info criterion	-2.221
Prob (F-statistic)	0.000		Schwarz criterion	-1.882
SCF(2,17)=1.591	P=0.233		Hannan-Quinn crit.	-2.124
HF(6,19)=1.094	P=0.401		MF(1,18)=1.183	P=0.291
JB=0.159	P=0.923		CF=4.183	k=1
ARDL(1,4)				

Note: Equation 3 is of interest with double exponentially smoothed logged Direct Taxes (where LN stands for natural logarithm). See Note to Table 3 for the meaning of test symbols and critical values for cointegration.

Table 5: ARDL(2,0) of Double Exponential Smoothed Logged Indirect Taxes (LNITSM)

Variable	Coefficient	Std. Error	t-Statistic	Prob
D(LNITSM (-1))	0.366	0.139	2.629	0.015
D(LNGDP)	0.548	0.122	4.473	0.000
CointEq (-1)	-0.485	0.101	-4.793	0.000
LNGDP	1.130	0.057	19.991	0.000
C	-3.075	0.506	-6.076	0.000
R-squared	0.987		Mean dependent var	6.952
F-statistic	596.413		Akaike info criterion	3.283
Prob (F-statistic)	0.000		Schwarz criterion	3.093
SCF (2,22) =0.044	P=0.957		Hannan-Quinn crit.	3.225
HF (3,24) =0.346	P=0.792		MF (1,23) =1.928	P=0.178
JB=0.805	P=0.669		CF=11.027	k=1
ARDL (2,0)				

Note: Equation 3 is of interest with double exponentially smoothed logged indirect taxes (where LN stands for natural logarithm). See Note to Table 3 for the meaning of test symbols and critical values for cointegration.

Results of Elasticities for Single Dummy Variable Approach for Direct and Indirect Taxes

Table 6: ARDL (4,1,2,1) Cointegrating and Long-Run Form for Logged Direct Taxes, Barbados with Dummy, 1990-2019

Variable	Coefficient	Std. Error	t-Statistic	Prob*
D (LNDT (-1))	0.073	0.155	0.473	0.644
D (LNDT (-2))	0.148	0.134	1.102	0.289
D (LNDT (-3))	0.286	0.129	2.214	0.044
D(LNGDP)	-0.069	0.421	-0.164	0.872
D (LNGDP (-1))	0.819	0.435	1.881	0.081
D(DU_DT)	3.863	1.246	3.101	0.008
D (DU_DT (-1)	-0.071	0.029	-2.416	0.030
D(DU_DTxLNGDP)	-0.434	0.140	-3.112	0.008
CointEq (-1)	-0.819	0.124	-6.621	0.000
LNGDP	0.915	0.090	10.173	0.000
DU_DT	1.317	1.518	0.867	0.400
DU_DTxLNGDP	-0.129	0.168	-0.766	0.456
C	-1.538	0.808	-1.904	0.078
R-squared	0.981		Mean dependent var	6.647
F-statistic	63.904		Akaike info criterion	-2.646
Prob (F-statistic)	0.000		Schwarz criterion	-2.066
SCF (2,12) =1.632	P=0.236		Hannan-Quinn crit.	-2.479
HF (11,14) =1.133	P=0.406		MF (1,13) =2.569	P=0.133
JB=1.377	P=0.503		CF=9.026	k=3
ARDL (4,1,2,1)				

Note: Equation 3 is of interest with dummy (DU_DT for discretionary tax changes in Direct Taxes and LN stands for natural logarithm). See also Note to Table 3 for the meaning of test symbols and Note to Table 5 for critical values for cointegration.

Table 7: ARDL (1,1,0,2) Cointegrating and Long-Run Form for Logged Indirect Taxes, Barbados with Dummy, 1990-2019

Variable	Coefficient	Std. Error	t-Statistic	Prob*
D(LNGDP)	1.452	0.341	4.258	0.000
D (LNGDP (-1))	-0.530	0.323	-1.642	0.116
D(DU_IT)	-1.118	0.764	-1.463	0.159
D(DU_ITxLNGDP)	0.127	0.086	1.486	0.153
D (DU_ITxLNGDP (-1))	-0.007	0.003	-2.070	0.052
CointEq (-1)	-0.826	0.179	-4.606	0.000
LNGDP	1.116	0.073	15.238	0.000
DU_IT	-1.353	0.872	-1.552	0.136
DU_ITxLNGDP	0.167	0.099	1.690	0.107
C	-3.0260	0.6600	-4.5820	0.0000
R-squared	0.980		Mean dependent var	6.944
F-statistic	139.707		Akaike info criterion	-2.553
Prob (F-statistic)	0.000		Schwarz criterion	-2.173
SCF (2,18) =0.978	P=0.395		Hannan-Quinn crit.	-2.437
HF (7,20) =1.207	P=0.344		MF (1,19) =0.925	P=0.348
JB=3.772	P=0.151		CF=4.612	k=3
ARDL (1,1,0,2)				

Note: Equation 3 is of interest with dummy (DU_IT for discretionary tax changes in Indirect Taxes and LN stands for natural logarithm). See also Note to Table 3 for the meaning of test symbols and Note to Table 5 for critical values for cointegration.