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Constructing country-specific debt sustainability indices for developing countries

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Abstract

Contemporary crises continue to keep governments in protracted periods of borrowing, increasing the stock and flow of sovereign indebtedness. Single metrics of public debt – such as the debt-to-GDP ratio – provide an incomplete profile of a nation's debt position, which is largely determined by country-specific factors. We consolidate various indicators of public debt to construct a novel debt sustainability index and its companion debt volatility index. We demonstrate our approach, based on principal component analysis, using a natural resource-rich but relatively data-poor country – Trinidad and Tobago – where debt management is a recurring macroeconomic concern, but comprehensive debt indices remain unavailable. The movements in our indices align with historical episodes that would influence country-specific public debt levels. Our approach is straightforward to adapt and apply to developing countries, where a uniform measure of debt is either unavailable or provide an incomplete perspective of fiscal stress when such a measure exists. We further illustrate the usefulness of the constructed indices by investigating the debt-growth nexus. Consistent with economic theory of countries with relatively lower debt levels, our novel debt indices for this country provide evidence of a positive, significant, and robust impact of debt on growth when the traditional debt-to-GDP measure suggests none.

Keywords: debt sustainability; fiscal stress; index; principal component analysis; public debt

JEL classifications: C38; C43; H63

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1. Introduction

THE COVID-19 pandemic resulted in increased government borrowing to fund extraordinary stimulus packages to cushion its impact. Inevitably, this led to higher public debt levels in the last few years and debt is expected to remain elevated in the short to medium term (IMF, 2023). Rising debt was also a concern in the aftermath of the 2008 Global Financial Crisis and it served as a principal pre-crisis risk factor for the sovereign debt crisis in Europe (Lane, 2012). Indeed, fiscal actions in the aftermath of crises renews the interest of macroeconomic research on the debt-growth nexus, debt sustainability and fiscal discipline, and the pathway for returning sovereign debt to sustainable levels. Prior to contemporary crises like the pandemic and the European sovereign debt crisis, studies on debt sustainability were infrequent, especially relative to research in other macroeconomic areas such as monetary policy. Yet, much of the literature in assessing debt, fiscal sustainability, and the related growth implications focus on the gross debt to gross domestic product (debt-to-GDP) ratio as the most common metric of government indebtedness (see, e.g., Baum et al., 2013; Chudik et al., 2017).

While we acknowledge that debt-to-GDP is the most used indicator of government debt, its potential to assess debt sustainability as a sole debt metric may be hindered by its limited ability to characterise the more complete public debt profile of a country. One of the contributions of this paper is that we present a critical review of the debt-to-GDP indicator. To the best of our knowledge, we are the first to provide an extensive critical review and assessment of the debt-to-GDP ratio. Another significant contribution is that we provide an easy to adapt and apply approach for constructing comprehensive and country-specific debt sustainability and volatility indices for developing countries, where uniform measures of debt tend to be either unavailable or would be unreliable in correctly reflecting public debt in the context of that nation.

For an indicator to accurately reflect government debt, it would need to be reflective of a country-specific conditions. Importantly, Lojsch et al. (2011) identify measurement and other deficiencies from investigating the size and composition of debt in the Euro area and recommend that the focus should be on multiple government debt indicators to capture a true picture of the level of indebtedness. Moreover, Vidal & Marshall (2021) contribute to the debt sustainability debate, highlighting that debt sustainability as a function of market production is undermined by methodological and logical inconsistencies. They propose that social ontologies may provide a better understanding of debt sustainability, as it is a social phenomenon based on social agreements. While it is a complex task to locate sufficient empirical data to support debt as a social phenomenon, we particularly agree with the argument that there are methodological inconsistences in understanding public debt sustainability. We also argue that there are deficiencies in the focus on debt-to-GDP as the primary indicator of government indebtedness.

In addition, Schaltegger & Weder (2015) use a variety of fiscal indicators including international reserves, short-term debt, debt-to-GDP, and fiscal adjustments as they investigate sovereign default across a dynamic panel of 104 developing countries. Building on this work, Lau et al. (2022) also investigate the relationship between debt and economic growth in developing economies across Asia. In addition to using debt-to-GDP, the latter analysis includes debt-to-reserves as another indicator applicable to developing Asian economies, since the total debt stock is typically dominated by external borrowing. Also recognising the need to identify optimal indicators for measuring public indebtedness, Xiong et al. (2023) use debt-to-revenue as a measure of indebtedness to analyse the relationship between fiscal gaps and public-private partnerships in Chinese prefecture-level cities.

We posit that it is important for the indicator of government debt to be comprehensive and reflective of country-specific conditions. Such an index will provide a more complete and holistic measure of the debt position of municipalities or the public sector. Indeed, an index can reflect a concept much better than a single indicator or group of indicators. Related work to develop a consolidated index on trust is demonstrated in Makrychoriti et al. (2022), who investigate the relationship between financial stress and economic growth across a sample of EU countries and adopt the financial stress index from the European Central Bank following the methodology of Duprey et al. (2017). They make use of principal component analysis (PCA) to construct an index of trust from four trust indicators. As it relates to debt sustainability, there are several indices such as the fiscal stress index, the external debt vulnerability index, and the fiscal distress index but the scope of such indices remains limited.

Hence, building on the proposition of methodological inconsistences by Lojsch et al. (2011) and Vidal & Marshall (2021), while being conscious of the potential issues to developing countries in applying studies such as Lau et al. (2022), we draw on the PCA approach of Makrychoriti et al. (2022) and propose a novel concept of a consolidated debt sustainability index (DSI) and its companion debt volatility index (DVI) for developing countries and small states with limited data availability. We present the steps in constructing the DSI and DVI in detail and apply it to Trinidad and Tobago – a small and open petroleum-exporting economy that is prone to procyclicality of fiscal policy with international commodity price cycles. Yet, it is straightforward to adapt and apply the DSI and DVI construction steps we put forward in this paper to any developing country. We follow this with a brief application of the DSI and DVI to assess the debt-growth nexus in Trinidad and Tobago.

The remainder of this paper is structured as follows: in section 2, we highlight how estimation results may change with alternative indicators and the benefits and drawbacks of the debt-to-GDP ratio as the main indicator of government debt. Section 3 follows with a review of the literature on related debt indices. In section 4, we outline the steps to develop the DSI and DVI that can be applied to any developing economy. We then use Trinidad and Tobago as a case study to construct the novel indices in section 5 and adopt the DSI and DVI to investigate the debt-growth nexus of this country in section 6. We conclude in section 7.

2. Critical review of the most common debt indicator – the debt-to-GDP ratio

Debt sustainability is important to a government so that they can understand debt trajectories and pathways, and optimal financing options to support macroeconomic soundness. Interestingly, the empirical literature leans towards debt-to-GDP as the sole metric for government debt, despite the availability of other recognised measures of government indebtedness such debt-to-revenue, debt-to-exports, the debt-service ratio, and the like (IMF, 2003). Throughout the literature, debt sustainability is assessed through the change in the fiscal stance resulting from changes in government debt and the consensus indicator of government debt is debt-to-GDP (see, e.g., Celasun et al., 2006). In fact, most studies encompassing government indebtedness often use the debt-to-GDP indicator as the sole metric such as Garbellini (2016) while investigating the relationship between government debt, public expenditure, and fiscal multipliers. Similarly, Panizza & Presbitero (2014) use the debt-to-GDP metric in their assessment of the debt-growth nexus. However, the empirical landscape reveals varied findings and highlights the need for a more comprehensive understanding of debt, incorporating various metrics beyond the traditional debt-to-GDP ratio.

Unsurprisingly, the empirical literature has produced differing results when using the debt-to-GDP ratio to capture government debt. For example, Ciżkowicz et al. (2015) use a fiscal reaction function to assess debt sustainability in 12 Euro area member countries while separating them into core and peripheral countries. The authors find conflicting results between the two groups where the peripheral countries' fiscal stance did not respond to changes in debt-to-GDP while the core group display fiscal sustainability. Similarly, Schaltegger & Weder (2015) investigate the use other indicators of debt sustainability for developing economies and find similar inconclusive results for debt-to-GDP in predicting the probability of sovereign default. Even in the presence of adverse shocks or conditions, no significant relationship may exist between government debt and the fiscal response. For instance, in Zhang et al. (2023), a panel of 170 countries is used to investigate the relationship between fiscal capacity, the COVID-19 pandemic, and government spending and they find that the fiscal balance and government debt did not impact fiscal spending during the pandemic. These mixed results throughout the literature are influenced by country specific factors across a heterogenous group of countries that debt-to-GDP as the sole metric may not capture.

In response to the insignificance and shortcomings of debt-to-GDP, authors are recognising that alternative indicators of indebtedness may be better suited for analysis and perhaps account for some of the heterogeneity across a diverse group of countries. Given the diverse sample across 104 developing economies, Schaltegger & Weder (2015) use more pertinent indicators of indebtedness to complement debt-to-GDP including international reserves and short-term debt and find that they are indeed significant at predicting the probability of sovereign default compared to the insignificant debt-to-GDP ratio.

The literature on government debt indicators reflects a dynamic landscape, with debt-to-GDP serving as a cornerstone metric but not without its shortcomings. The increasing use of alternative indicators in empirical studies underscore the importance of considering the heterogeneity of countries. Looking ahead, a comprehensive understanding of government debt demands a multi-faceted and multi-pronged metric that goes beyond the conventional debt-to-GDP paradigm, considering diverse economic and contextual factors that influence the fiscal health of nations.

In what follows, we provide a critical assessment of the debt-to-GDP ratio as the sole indicator of indebtedness. Government debt may be difficult to compare in monetary terms across countries and time due to differences in exchange rates, inflation rates, and other determinants and compositions of government debt. As such, it is recommended that the debt stock be normalised by a country's repayment capacity. In terms of data collection and debt management, GDP is the most common normalisation factor used (Amegashie, 2023). Domar (1944) first propose this idea by comparing debt, and its related burdens to national income, and economic growth. Similarly, it is common to normalise the government's budget constraint using GDP (Ley, 2005). It is also adopted as part of the conventional accounting approach to debt sustainability analysis (Cassimon et al., 2008). As such, the most common metric used to capture government's debt is given by:

$$Debt-to-GDP \;= \frac{Gross\ government\ debt}{Nominal\ GDP} \qquad (1)$$

A key advantage of debt-to-GDP is that it is a common metric that is easy to compute and interpret as a simple ratio of the country's indebtedness to a measure of the country's repayment capacity. At a gross and aggregate level, debt data is more readily available when compared to other forms of debt data including net debt, debt by maturity, and the composition of debt. GDP is a key indicator for analysing macroeconomic performance, and it is one of the most available macroeconomic statistics that is estimated by a country's national statistical office.

However, debt-to-GDP can be a misleading indicator of government's debt. The ratio assumes that all the country's GDP can go towards servicing government's debt, but this is an unrealistic assumption. Debt is recorded at a point in time (stock) whereas GDP is recorded over a period (flow). This implies that the ratio will capture how many years the country's GDP will take to repay existing debt, but it is unrealistic to allocate the entire economy's GDP towards servicing debt as there are many elements of GDP that a government cannot access and use for debt repayment (Bhatt & Neveu, 2019). GDP is often used as a proxy for the government's repayment capacity but there is no need for a proxy for government's repayment capacity when it can be accurately captured in the form of government's revenue. Especially for low-income countries, there is a weak correlation between GDP and government's revenue since tax buoyancy is usually lower resulting in less marginal tax revenue changes from an increase in GDP (Dudine & Jalles, 2017). As such, GDP may not accurately capture the government's ability to service debt.

Despite being a widespread representation of the government's repayment capacity, accurately estimating GDP continues to be a challenge (see, e.g., Chang & Li, 2018). In particular, countries face challenges in terms of capturing the output of the economy as a whole, as well as estimating the value added at each stage of the production process. The sample size, frequency and quality of data used to estimate GDP can often be significantly different from actual GDP and these issues are worse for developing countries.

Furthermore, the debt-to-GDP metric does not capture the duration of debt. Duration refers to the sensitivity of debt instruments, such as bonds, to changes in the interest rate. For an indicator of government debt to be comprehensive, it should capture the duration of debt over time since changes in duration can affect a government's decision to finance as well as the cost of financing since duration is independent of debt (Bhatt & Neveu, 2019). Simply put, the debt-to-GDP as a standalone metric ignores one of the key factors influencing debt and its sustainability, which is the cost of debt or the interest rate.

Debt-to-GDP is an aggregate metric that does not capture the maturity structure of debt by specifically identifying short-term debt versus long-term debt. Short-term debt is usually associated with different interest rates and instruments compared to long-term debt. Short-term debt ignores rollover risks which is highly correlated with sharper economic contractions and greater probabilities of crises with the potential to adversely affect the economy's long-term performance (see, e.g., Brunnermeier, 2009). By ignoring the maturity structure of the instruments that comprise of gross debt, governments are overlooking the adverse effects of having a debt structure that is heavily comprised of short-term debt relative to long-term debt and this was evident during the pandemic as governments acquire short-term debt to fund fiscal stimulus.

Debt-to-GDP does not capture the composition of debt as well. Debt issued in domestic or foreign currency has implications for crises, defaults, and repayment obligations (see, e.g., Vasishtha, 2010). With the aim of minimising the overall cost of debt, reducing rollover risks, and balancing the cost-risk trade-off, debt officials and managers favour domestic debt over foreign currency debt. Debt issued in domestic currency is viewed as being more prudent for both advanced and emerging market economies (Alesina, Broeck, et al., 1992). As such, fiscal vulnerabilities and the probability of crisis is lower where debt issued in domestic currency accounts for a substantial portion of total debt. However, the overall debt-to-GDP metric does not capture the decomposition of debt issued in domestic or foreign currencies.

Another limitation of the debt-to-GDP metric is that gross debt can sometimes offer a limited or partial view of the fiscal risks facing a government (Bloch & Fall, 2016). It fails to account for receivables owed to the government as well as assets the government may hold that can potentially aid their repayment capacity (de Matos et al., 2016). To truly consider the repayment capacity and solvency of the government, the liabilities of the government must be net of the financial assets of the government at market value. These financial assets include currency and deposits, accounts receivable, and shares and equity. To further estimate the government's true net worth, non-financial assets can also be considered. However, data collection on these assets is very limited and it may be difficult to determine its market value, especially for developing countries. The gross debt value does not capture contingent or hidden liabilities as well. Contingent liabilities are those liabilities that are conditional on some event occurring, and the parameters of these events may not be completely predictable. Common contingent liabilities include pensions which are triggered at a certain age with minimum contributions and publicly guaranteed debt which are triggered by a condition to the guaranteed institution such as defaults or bankruptcy. Considering these contingent liabilities as part of government debt will increase the debt-to-GDP ratio and require higher primary surpluses and a greater contribution of GDP to meet debt obligations. Without this information, determining an initial and comprehensive government debt ratio may be difficult and this is crucial for fiscal planning for a debt convergence path towards debt sustainability.

Debt transparency continues to be an issue, especially in low-income countries with insufficient operational risk management policies, deficient debt governance frameworks, and inadequate audits. More than twenty countries do not publish debt data, and some of those countries that publish debt data do not comply with international standards, benchmarks, and best practices (Rivetti, 2022). If data is available, reporting is often limited to central government loans and securities. Despite decades of effort which lead to strengthening debt management and transparency policies, the goal of making information on public debt transparent and accessible remains far reaching. Based on comprehensive research from over 140 countries over a 50-year period, it was found that debt was continuously underreported or undisclosed (Horn et al., 2022). The frequency and size of the difference in public debt data from different sources is also well documented and concerning (Rivetti, 2022). Of particular importance is the continued underestimation of contingent liability risks as well as the increasing use of non-traditional instruments and lenders with non-disclosure agreements.

Debt-to-GDP continues to be the most common indicator used in the assessment of debt and fiscal sustainability due to its availability and advantages. However, there are limitations to both the numerator and denominator in the debt-to-GDP ratio. As such, central argument is for more robust measure of debt that is specific to the country's circumstances. For example, if the country has a high level of contingent liabilities and public guaranteed debt, this should be included in the computation of the country's debt stock. Similarly, if a country's debt profile favours the use of short-term debt, this should be reflected in its choice of a debt indicator.

Furthermore, the choice of alternative denominators is crucial since it reflects a country's repayment capacity, and it should be specific to the country's circumstances. For example, if a country faces foreign exchange constraints, export earnings may be a more appropriate measure of repayment capacity. Similarly, if the country faces fiscal constraints, government revenue may be a more appropriate denominator. For low-income and developing economies, multiple indicators with varying measures of debt and repayment capacity may be beneficial (IMF, 2003).

A general debt indicator can therefore be represented as:

$$Debt\ indicator = \frac{Debt\ stock\ or\ debt\ service}{Repayment\ capacity} \quad (2)$$

The debt stock or service can include gross debt, net debt, debt including contingent liabilities, interest expense, and other indicators of debt stock or debt expense. Furthermore, the repayment capacity can be captured by GDP, government revenue, foreign exchange reserves, exports, and other indicators of the country's repayment capacity. In Table 1, we present common debt indicators that can either be stock or flow from an accounting perspective. The stock indicators have at least one stock variable such as gross debt and international reserves which represents a snapshot at a point in time, while the flow indicators have two flow variables such as interest expense and all repayment measures that that capture movement over a period.

Table 1: Common debt indicators

Indicator	**Description**
Stock measures	
Debt-to-GDP	Ratio of gross debt to GDP.
Debt-to-exports	Ratio of gross debt to export earnings.
Debt-to-revenues	Ratio of gross debt to total government revenue.
International reserves-to-short-term debt	Ratio of gross international reserves to short-term debt.
Flow measures	
Debt service-to-exports	Ratio of principal and interest payments to export earnings.
Debt service-to-revenues	Ratio of principal and interest payments to government's revenue.
Interest service ratio (exports)	Ratio of interest payment to export earnings.
Interest service ratio (revenue)	Ratio of interest payment to government's revenue.

Source: consolidated from IMF (2003, 2014)

Furthermore, these indicators can be expanded to replace gross debt with net debt or adjusted to incorporate contingent and publicly guaranteed liabilities. Debt service can include interest only or interest and principal repayment as a percentage of the repayment capacity. While there are similar limitations of these indicators including debt transparency and reporting issues, they overcome several of the problems of using debt-to-GDP as the sole indicator of the government's debt burden by including government's financial assets to create net debt-to-GDP, more reflective indicators of the government's repayment capacity including government's revenue and export earnings, implicitly capturing duration with the interest service ratios, and maturity by examining short-term debt separately with the international reserves-to-short-term debt ratio.

3. Indices in fiscal and debt issues

Indices relating to issues of debt and fiscal vulnerabilities and stresses are marked by limited literature. Indeed, there are few available indices but there is a consensus that they provide signals or early warning indicators, and guides government policy decision making. However, their methodologies and focus are quite diverse. Baldacci et al. (2011) presents one of the earlier index which focuses on fiscal stress. It is designed as an early warning signal of sustainability issues for both developing and developed countries. Broadly speaking, the authors describe fiscal stress as a situation where an event endangers government debt solvency, necessitating fiscal policy adjustments. In a similar vein, Doemeland et al. (2022) adopts a default view of sustainability but for market assess countries only. Notably, their view of debt vulnerability is panoramic, and they propose that overall debt vulnerability is multi-faceted, which includes four sub-indices including the fundamental index, probability of default index, the count index, and the theory index, with probability of default index conspicuously similar to the fiscal stress index by Baldacci et al. (2011).

In contrast, Blanchard & Das (2017) narrow their focus to external debt and create an index of external debt sustainability. Contrary to the fiscal stress index and the debt vulnerability index which underscores overall solvency, they describe external debt sustainability as a situation where net debt does not exceed the present value of net exports. This study by Blanchard & Das (2017) addresses a notable gap in the literature which gives inadequate consideration for exchange rate movements, and they go on to explicitly incorporate the uncertainty of the exchange rate through a distribution of exchange rates generated from the variance-covariance matrix of a Vector Autoregression (VAR). In addition to the academic literature, multi-lateral lending institutions such as the Caribbean Development Bank (CDB) explore the use of debt indices in their assessment of borrowing member countries access to funding. Quite similar to the fiscal stress index from Baldacci et al. (2011) and the probability of default sub-index from Doemeland et al. (2022), the CDB define fiscal distress as 'any form of fiscal and debt unsustainability' where the country cannot repay, or the country is having difficulty in repaying its debt.

As expected, a common theme exists across the choice of indicators for constructing the indices. For example, the CDB (2012) construct a fiscal distress index using standard debt indicators that capture both liquidity and solvency. These include debt-to-GDP, the primary balance, real GDP growth rates, and the interest rates. Baldacci et al. (2011) focus on fiscal indicators such as the interest-growth differential, debt-to-GDP and the cyclically adjusted primary balance. However, the indicators then diverge based on the focus on each index. For instance, the Caribbean suffers from fiscal and debt issues due to structural inefficiencies, susceptibility to natural disasters and slow growth, which results in the CDB including a fiscal adjustment variable that captures the difference between the primary balance required to achieve debt reduction and the actual primary balance. The CDB also include a debt distance variable which represents the difference between the current debt level and a benchmark of 60 percent. Since Baldacci et al. (2011) include developed countries in their study, they incorporate indicators that capture asset and liability management and long-term fiscal trends. Blanchard & Das (2017) did the same, with the addition of exchange rates distribution. Similarly, Doemeland et al. (2022) include credit default swaps and emphasise thresholds in their analysis as they aim to assess the probability of defaults.

Methodological approaches, particularly weighting, are of paramount importance as inaccurate weights can distort results. Surprisingly, the choice of weights varies substantially. For example, the CDB adopt a simple equal-weight approach while Baldacci et al. (2011) adopt a more complex approach and derive weights from the signalling power of each indicator. Borrowing from other fields such as finance and social research, Doemeland et al. (2022) opt for a neutral approach, letting the indicators themselves determine the weights using Principal Component Analysis (PCA). Perhaps the most complex method, relative to the other approaches is adopted by Blanchard & Das (2017) as they use a VAR with a vector of endogenous variables and take the joint distributions from the estimation of the VAR equations and its associated variance-covariance matrix to create stochastic simulations to obtain the exchange rate distribution and hence capture uncertainty.

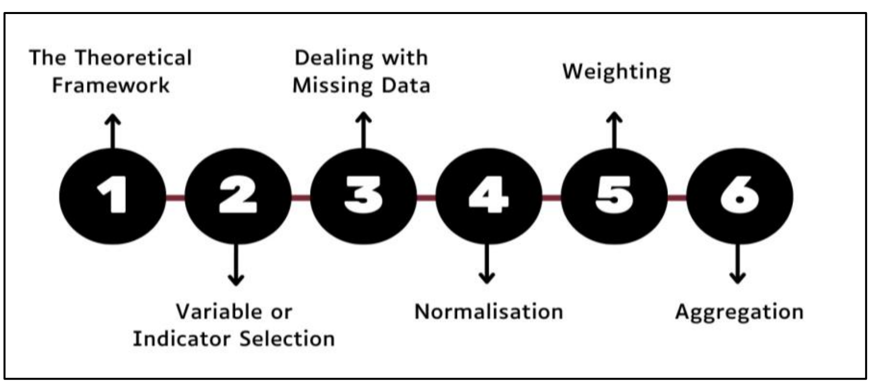
Each index, despite deferring methodologies and indicators, perform well and successfully serve its intended purpose. For example, Baldacci et al. (2011) find that gross financing needs and fiscal solvency risks were the primary contributors to fiscal stress in developed countries while public debt structure and spillovers from the global financial market were the main contributors of fiscal stress for developing countries. In their case study of Chile and the U.S., Blanchard & Das (2017) find robust evidence that the sustainability of external debt is heavily dependent on the capital account as opposed to the current account since adjustments in capital account can easily offset any adjustment in the trade balance.

As we clearly demonstrate, the development of composite indices is not unique to assess fiscal and debt vulnerabilities given the number of debt indicators that a country can measure or capture. Conclusively, the literature illustrates that indices are constructed for different purposes including capturing the current debt situation, to provide an early warning system or to predict the probability of crises. As such, we aim to construct a novel DSI in this paper that ultimately provide a more comprehensive list of indicators and overcome any shortcomings in the debt-to-GDP ratio. Our DSI is particularly suited for developing countries and small states using low frequency (annual) data that captures both liquidity and solvency.

4. Constructing a country-specific debt sustainability index (DSI)

In this section, we highlight the steps to construct a composite index that captures debt sustainability, particularly for developing economies and small states with limited data availability and frequency. While there are several definitions of a composite index, Freudenberg (2003) provides one of the simplest definitions which states that '*composite indicators are synthetic indices of individual indicators.*' From the simplest definitions to the more complex ones, a common element emerge that a composite indicator captures a complex system of components that is easier to understand as an index instead of individual indicators (Greco et al., 2019). A composite indicator can serve as a useful tool to perform government policy analysis, and easy and clear public communication for a complex issue such as debt sustainability where several indicators exist. Using the OECD (2008) framework for constructing indices, we construct the DSI using the six steps outlined in Figure 1.

Figure 1: Steps in constructing an index



Source: adopted from OCED (2008)

Step 1: The Theoretical Framework

The first step we take in constructing the DSI is creating the theoretical framework to identify and define the concept being measured as well as the selection criteria for the underlying indicators. Celasun et al. (2006) defines debt sustainability as a situation where the present value of future revenues is able to cover the current debt stock and future commitments. The current payment captures the liquidity element of debt sustainability while the future obligations capture the solvency element of debt sustainability. The DSI aims to provide a comprehensive measure that captures both liquidity and solvency.

Step 2: Variable/Indicator Selection

The next important step is the selection of variables or indicators. Garbage in results in garbage out and high-quality indicators are key to the creation of a robust composite index. The quantitative or hard input indicators we select to reflect sustainability includes gross debt-to-GDP, gross debt-to-revenue, gross debt-to-exports, external debt-to-energy exports, external debt-to-exports, and external debt to gross international reserves. These indicators were largely selected based on potential data availability for developing economies and small states. It features multiple measures of repayment capacity as well as explicitly identifies debt denominated in foreign currency relative to the stock of foreign reserves. As such, it improves on some of the limitations identified earlier on the use of the gross debt-to-GDP ratio only. These indicators are also analytically sound and globally recognised as key indicators for capturing government indebtedness. They are widely accessible through domestic agencies such as Central Banks and Ministries of Finance as well as external data sources such as the IMF and the World Bank. In the absence of these variables, a subset can be used or similar variables that capture debt and country specific ability to service debt.

Step 3: Dealing with Missing Data

The third step deals with issues relating to missing data that can either be random or non-random. However, given the choice of indicators selected, we do not expect missing data to be an issue since it may either be captured and recorded by domestic institutions or estimated by an international financial institution. However, missing data can distort composite indices and as such, the issue of missing data must be addressed if it exists. At the end of this step, the dataset must be complete with no missing values, or any issues of missing values addressed. Any adjustments must be detailed and documented for transparency and replicability. As the quality of debt recording data improves, the composite index should improve in parallel.

Step 4: Normalisation

After all data issues are identified and addressed, the next step involves converting the data into a common, comparable form to avoid mixed measurement problems relating to units, scales, and ranges. Normalisation also helps eliminates extreme values or outliers from the indicators (Freudenberg, 2003; Jacobs et al., 2004). Of the normalisation methods available, standardisation and min-max are the two most appropriate methods based on the debt indicators used for constructing the DSI. Standardisation or the standard deviation approach assumes that the indicators are normally distributed through the imposition of the standard normal distribution with a mean of zero and a standard deviation of one. It is computed as:

$$Z_t = \frac{x_t - \mu}{\sigma} \tag{3}$$

Where x_t is the indicator value at time t and μ and σ are the period mean and standard deviation respectively. Positive Z-scores illustrate that the indicator is above the period average while negative Z-scores illustrate that the indicator is below the period average.

The min-max approach is similar to the standardisation approach, but it makes no distribution assumptions. It assesses the current indicator (x_t) distance from the minimum value ($\min$) of the indicator relative to the range of the indicator ($\max - \min$). It is computed as:

$$I_t = \frac{x_t - min}{max - min} \tag{4}$$

Following the work of Baldacci et al. (2011) and CDB (2012), the standardisation approach will be used to construct the DSI. However, as a measure of robustness, the min-max approach will be used to compare the overall movement and patterns in the DSI between the two normalisation methods.

Step 5: Weighting

The next critical step in the construction of the DSI is the weighting of the indicators for the index. The most commonly used weighting method for a composite index is equal weighting. This is largely due to its simplicity and high degree of objectivity. It is also useful for indices where alternative weighting schemes cannot be justified. However, equal weighting can be viewed as an oversimplification of the index by treating all indicators as equal when some indicators may be more important than others (Paruolo et al., 2013).

Given the nature of the index and the use of economic data, Principal Component Analysis (PCA) would be the most appropriate choice for weighting the DSI if there is high correlation between the selected indicators. PCA is a statistical approach to reduce data dimensions by capturing the highest variance in the least dimensions. PCA creates a system of equation where the first equation will capture the most variance and each subsequent equation within the system will capture the variance not captured by the previous equation. PCA is quite popular and prevalent in the applied literature on index construction given is convenience (using statistical software), transparency and relative objectivity (Greco et al., 2019). However, PCA cannot be used if the indicators have low correlation. In some instances, the PCA can produce negative weights and when this occurs, PCA should not be used. As a measure of robustness, an equal weighting approach can also be used to compare the trends and movements with the PCA index.

Step 6: Aggregation

The final step in the construction of the DSI is the aggregation of the weighted indicators. The linear method of aggregation is the most used where the composite is simply the sum product of the weights and indicators using an additive utility function. Following the CDB (2012), the linear approach will be utilised given the number of variables and the nature of the variables as it relates to macroeconomic computations. The linear approach is also well suited when the indicators have the same units of measurement. Furthermore, PCA and its derived components are computed using a linear aggregation approach to produce the overall index.

5. Index construction application: Trinidad and Tobago

The primary purpose of the DSI is to provide a more comprehensive measure that captures the debt position of a country, identify the trends in government debt and ultimately assess fiscal sustainability within a fiscal reaction function. For developing countries such as Trinidad and Tobago, there is a high probability of data availability at low frequency (annually) on debt indicators from Table 2, including debt-to-GDP, debt-to-revenue, debt-to-exports, interest-to-revenue, external debt-to-exports, external debt-to-energy exports, and external debt-to-reserves. As such, we use these variables to construct the DSI for Trinidad and Tobago between 1970 and 2021, which represents just over five decades of economic history.

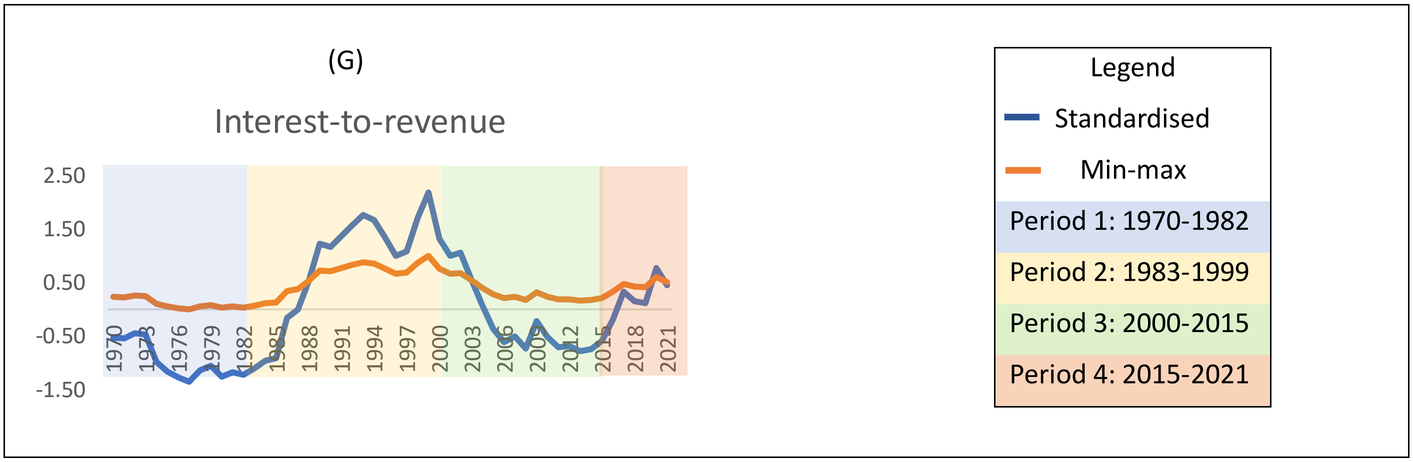
Table 2: Debt indicators for Trinidad and Tobago

Indicator	**Description**
DTR (Debt-to-revenue)	Ratio of gross debt to total revenue.
DTX (Debt-to-exports)	Ratio of gross debt to total exports.
DTG (Debt-to-GDP)	Ratio of gross debt to GDP.
ITR (Interest payments to revenue)	Ratio of interest payments to total revenue.
EDEE (External debt to energy exports)	Ratio of external debt to energy exports.
EDE (External debt to exports)	Ratio of external debt to total exports.
EDRES (External debt to gross official reserves)	Ratio of external debt to gross international foreign exchange reserves.

There are no issues of missing data, so we standardise the selected variables as the primary normalisation method. As a measure of robustness, we also normalise the variable using the min-max approach and we display the results in Figure 2.

We select these variables based on data availability, its use in the literature and relevance to the Trinidad and Tobago economy. For the seven indicators, normalisation using the standardisation and min-max approach result in the standardised values being higher than the min-max values when the trend is increasing and the converse when the trend is decreasing. This is largely due to the difference in the scaling factor (denominator) for both normalisation methods where the standard deviation from the standardisation approach is smaller than the range from the min-max approach. As such, it results in more extreme values. However, both normalisation methods display similar trends in all indicators for the DSI.

Figure 2: Normalised debt indicators



Without a doubt, the most used indicator of government debt is the debt-to-GDP ratio (see, e.g., Celasun et al., 2006; Paret, 2017). Other popular indicators include debt-to-exports (Bhering et al., 2019; Morlin, 2022) and especially when examining debt at the municipal level, debt-to-revenue is common (Xiong et al., 2023). Less popular indicators include external debt-to-exports (Dooley et al., 1986). The other three indicators we select, namely external debt-to-energy exports, external debt-to-reserves and interest-to-revenue are nearly non-existent in the empirical literature, but similar indicators are identified by the IMF (2003, 2013) to capture indebtedness.

All the indicators we select, in one way or another, follows trends in the oil cycle, capital expenditure on mega-projects and the behaviour of foreign exchange reserve accumulation. Interestingly, between 1970 and 1982 (Figure 2 - period 1), all debt indicators in panels A-G are below the period average as government revenue exceed expenditure resulting in an overall budget surplus of approximately 0.9% of GDP over the period. Furthermore, period 1 coincides with external debt service averaging 2.6%, and debt-to-GDP averaging 16.0%. Macroeconomic and fiscal performance over period 1 was sound as development takes place across the energy sector such as the creation of state energy companies to meet the needs of a plethora of new oil and gas discoveries. The stellar performance of the economy results in a large and rapid accumulation of foreign exchange reserves causing import cover to increase from 2.3 months in 1970 to 19.5 months in 1981.

The subsequent two decades (Figure 2 - period 2) witness an increase in all debt indicators (panels A-G), coinciding with frequent sharp movements related to economic shocks. A sharp fall in oil price in the mid-1980s lead to a cumulative 25.0% decline in real GDP between 1982 and 1993. Following a 37.0% increase in external debt and a depletion of international reserves from US$2 billion to US$300 million, Trinidad and Tobago receive IMF assistance in 1988. Structural adjustments ensue, including cuts to social development and public expenditure, along with temporary wage reductions, and rising interest rates. Maintaining the value of the fixed exchange rate prove to be difficult with depleting reserves resulting in an acceleration in the pace of adjustments in the early 1990s with the floating of the exchange rate in 1993 as well as income and value-added tax reform. Between 1983 and 1997, external debt service averages a startling 16.9% when compared to 2.6% in period 1. As a result of increasing gross debt, external debt, and interest service coupled with declining reserves, GDP and revenue, debt indicators in panels A-G trend upwards and fluctuate as reforms are implemented and by 1994, they show signs of improvements and Trinidad and Tobago experiences sustained growth for the first time in over a decade.

From 2000 to 2015 (Figure 2 - period 3), debt indicators in panels A-G revert to the mean on account of stellar macroeconomic performance albeit with minor hiccups, driven by the energy sector. The largest Liquefied Natural Gas (LNG) train in the world is operationalised and together with new oil discoveries, government revenue increase, and foreign exchange reserves accumulate. Surprisingly, the economy also achieves robust growth in the non-energy sectors including manufacturing and services. The increase in wealth and growth in earnings lead to several mega construction projects over the period. Between 2000 and 2015, external debt service average 2.6%, which is significantly lower than period 2 and similar to period 1. Over the same period, the monetary value of debt increases by 130.0% but this is met by substantive increases in GDP, revenue, exports, and energy exports resulting in marginal increases in debt-to-GDP, debt-to-revenue, and debt-to-exports. Interest-to-revenue was also low as the government was able to secure low-cost debt financing with long-term maturity.

From late 2014 onwards, macroeconomic conditions unravel following a plethora of external and internal issues. Oil prices plummet which lead to GDP, revenue, energy exports and total exports tumbling (Figure 2 - period 4). External debt balloon between 2015 and 2021, increasing by nearly 100.0% as the government refinance several loans which are approaching maturity as well as to stabilise declining foreign exchange reserves. The monetary value of total debt increases by 118.0% over the same period. To continue ongoing capital projects and maintain subsidies and welfare payments, the government operates with continuous budget deficits. Oil refining ceases in 2018 and natural gas production slows amid maturing gas fields and LNG shutdown. Foreign direct investment dwindles due to depleting gas reserves while other neighbouring territories such as Guyana and Suriname make new and large discoveries. A compounding effect is the relative unattractiveness of Trinidad and Tobago to non-energy investors due to high crime and corruption. This results in a gradual increase in all debt indicators between 2015 and 2020 (panels A-G). Then comes the shock of the COVID-19 pandemic which leads to a jump in the debt indicators which exhibit a sharp rise except for external debt-to-reserves (panel F) which increase slightly since the reserve assets represent a stock while the pandemic primarily shock flow indicators. In 2021 as the world return to some degree of normalcy, the debt indicators return to similar pre-pandemic levels.

We then test for correlation between the variables from Table 2 using the Pearson correlation test, as well as its non-parametric equivalent – Spearman correlation – which is robust to the heteroskedasticity known to afflict economic and financial time series (see, e.g., Mahadeo et al., 2019 and references therein). We find a high degree of correlation between most of the variables as shown in Table 3. As we expect, there is a high correlation (greater than 90.0%) between DTR, DTX and DTG as they share a common indebtedness measure in gross debt and the repayment variables (GDP, exports, and revenue) moves in the same direction. Moderately high correlation exists among the other variables such as ITR given that interest payments are dependent on the outstanding debt stock. EDEE and EDE are highly correlated with DTX since they share a common measure of indebtedness and total exports are largely driven by energy exports. EDRES is the outlier because of the repayment variable being the stock of international reserves which does not move with the current repayment variables, but it is accumulated over a period of time. Given the high correlation, we proceed to apply PCA to the 7 indicators from Table 2 and we display the results in Table 4.

Table 3: Correlation matrix – debt indicators (with Spearman correlation in the upper triangle and Pearson correlation in the lower triangle)

	DTR	**DTX**	**DTG**	**ITR**	**EDEE**	**EDE**	**EDRES**
DTR	1.0000	0.9180	0.9664	0.9086	0.8691	0.8374	0.5883
DTX	0.9054	1.0000	0.9409	0.8257	0.9765	0.9646	0.5551
DTG	0.9630	0.9419	1.0000	0.8664	0.8911	0.8646	0.5421
ITR	0.8607	0.7694	0.8451	1.0000	0.8088	0.7740	0.5782
EDEE	0.7980	0.9326	0.8581	0.7684	1.0000	0.9941	0.5811
EDE	0.7655	0.9208	0.8312	0.7249	0.9938	1.0000	0.5744
EDRES	0.1021	0.0991	0.0097	0.1226	0.1557	0.1402	1.0000

Notes: Darker shades show stronger levels of correlation between debt indicators.

The results from Table 4 show that we find two components and that the first two components (PC1 and PC2) account for 90.2% of the cumulative variations in the seven indicators. As a measure of robustness, we use a simple rule of thumb of 90.0% as well as the Joliffe criterion which supports components once the eigenvalues are above 0.70. Furthermore, we visually inspect the scree plot which hint to two components (see Appendix A1). We then compute the weights for each component and find that the first and second components will account for 84.0% and 16.0%, respectively.

Table 4: Debt sustainability index – PCA

Component	Eigenvalue	Difference	Proportion	Cumulative variance
1	5.3134	4.3109	0.7591	0.7591
2	1.0025	0.5741	0.1432	0.9023
3	0.4284	0.2265	0.0612	0.9635
4	0.2019	0.1752	0.0288	0.9923
5	0.0268	0.0035	0.0038	0.9961
6	0.0233	0.0195	0.0033	0.9995
7	0.0037	.	0.0005	1

Note: We use the Kaiser criterion which states that components with eigenvalues of at least one should be included within the index.

In Table 5, we show that each of the coefficients in PC1 has a positive and similar impact ranging from 0.38 to 0.42 except for external debt-to-reserves with a coefficient of 0.06. In PC2, we find that external debt-to-reserves has the largest coefficient of 0.99 while the other coefficients are small (positive or negative). We compute the PCA weights of each variable by squaring the coefficients of each component and weighing PC1 and PC2 by 84.0% and 16.0% respectively. We find that each indicator receives a weight between 12.0% to 16.0% using PCA. As a measure of robustness, we use equal weights of approximately 14.0%, and this is quite similar to the weights of the PCA.

The results in Figure 3 illustrate that the DSI computed using PCA and equal weights follow a similar trend. Between 1970 to 1984, and 2002 to 2016, the DSI is below zero demonstrating that debt indicators are below the period average while the DSI is above zero showing that debt indicators are above the period average between 1985 to 2002, and 2017 to 2021. We find that even though both methods follow a similar trend and behaviour, the PCA DSI has more extreme values, with higher positive values and lower negative values relative to the equally weighted DSI (Figure 3 - panel A). A key reason for these results from the PCA DSI is the use of the variance and the indicators contribution to variations whereas the equally weighted index does not measure the variance. As a measure of robustness, we repeat the analysis using the min-max approach to normalisation and find that the size and movement of the PCA DSI and equally weighted min-max DSI mirror each other (Figure 3 - panel B).

Table 5: Weighting of each indicator for PC1 and PC2 in the DSI

Variable	**PC1**	**Weight**	**PC2**	**Weight**	**Combined weight**
DTR	0.41	16.6%	-0.05	0.2%	14.0%
DTX	0.42	17.8%	-0.03	0.1%	14.9%
DTG	0.42	17.4%	-0.14	1.9%	15.0%
ITR	0.38	14.5%	0.00	0.0%	12.2%
EDEE	0.41	17.0%	0.05	0.2%	14.3%
EDE	0.40	16.3%	0.04	0.1%	13.7%
EDRES	0.06	0.3%	0.99	97.4%	15.9%

In the final step, we use linear aggregation to produce the DSI. Using PCA, the DSI is given as:

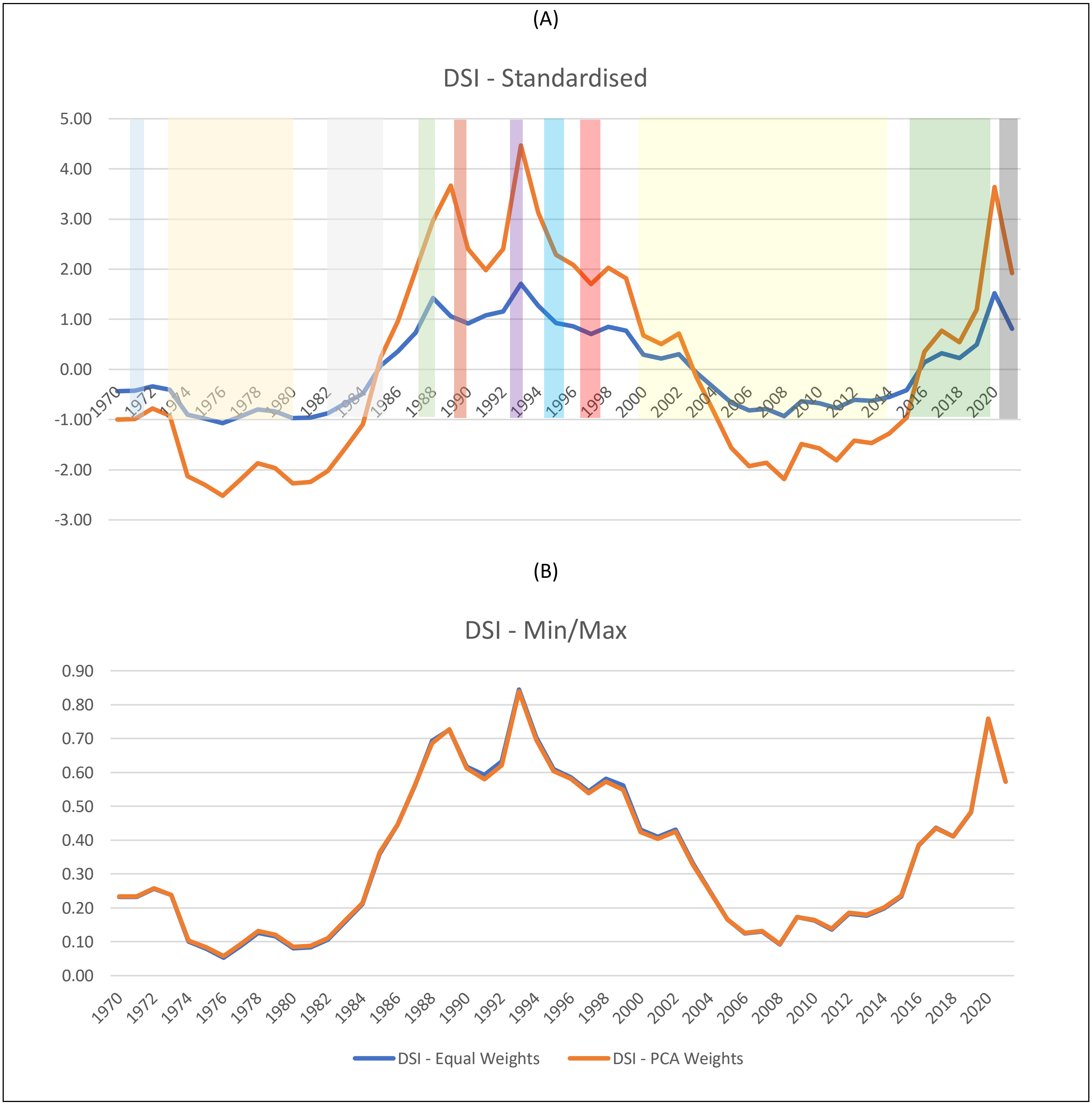
$$DSI = (0.84 \times PC1) + (0.16 \times PC2) \tag{5}$$

Using equal weights where Y_i is the standardised debt indicators, the DSI is given as:

$$DSI = \frac{\sum Y_i}{7} \tag{6}$$

The movement in the PCA DSI reflects key information content embedded in the seven indicators that would not have been captured if we use a single indicator. In panel A, sharp movements in the DSI coincide with major events and shocks in Trinidad and Tobago. For example, two of the most notable shocks are the IMF structural adjustment programme in 1988 and the change from a fixed to floating exchange rate in 1993. The results are massive spikes to external debt and deterioration in foreign exchange reserves, and this is captured by the DSI. The drastic fall in the DSI coincide with positive shocks to energy sector output such as the operationalisation of multiple LNG trains and a significant inflow of revenue from the energy sector. The fact that the DSI coincides with identifiable events that affect Trinidad and Tobago implies that we may be able to identify future movements and trends if other shocks occur.

Figure 3: Debt sustainability index (DSI)



Legend – *Shading flows in chronological order*
Macroeconomic performance is strong with significant infrastructural developments and rapid foreign exchange reserve accumulation.
Favourable sugar and oil prices and production.
1980s Oil Pirce War - Drastic fall in oil price with concurrent decrease in oil production.
IMF structural adjustment programme in 1988.
Attempted Coup d'état and significant decline in capital expenditure.
The exchange rate change from fixed to floating resulting in a sharp spike in the domestic dollar value of external debt.
External debt decline as the IMF loan is repaid. Income tax rates are lowered which results in an increase in revenue collection.
Large capital expenditure.
Low external debt service with few debt maturities. Capital expenditure is high with mega construction projects, but it is accompanied by elevated energy and non-energy revenue. Largest LNG train in the world is operationalised.
Treasury bill issuance increase by 135% to meet significant shortfall in revenue to continue to fund mega-projects.
Stimulus funding for COVID-19.

In addition to assessing debt sustainability, we investigate debt volatility by computing a companion debt volatility index (DVI). To begin, we examine the conditional volatility of the seven indicators in Table 2 by testing for Autoregressive Conditional Heteroscedasticity (ARCH) effects. However, four out of the seven indicators had no ARCH effects up to five lags and the remaining three indicators had some ARCH effects (see Appendix A2). Still interested in the volatility of these indicators, we proceed to examine moving unconditional volatility by using the simple but common method of a rolling standard deviation (see, e.g., Yeh et al., 2013) as the rolling standard deviation approach to volatility can sometimes closely approximate to more complex econometric models such as ARCH (William Schwert, 2002). Based on the literature, size of the dataset and the fact that political cycles are typically 5 years in Trinidad and Tobago and fiscal expenditure is tied to election periods, a 5-year rolling window can illustrate the punctuations in government spending, so we use a 5-year window to calculate the rolling standard deviation. This results in a sample spanning 1974 to 2021.

We proceed to construct the DVI by applying PCA to the 5-year rolling standard deviation as a measure of volatility and display the results in Table 6. We conclude that the DVI with the 5-year rolling volatility has two principal components ($PC_{DVI\,1}$ and $PC_{DVI\,2}$) derived from the seven indicators.

From Table 6, we calculate the weights of each component, and the first component has a weight of 79.2% and the second component has a weight of 20.8%. Both components combined accounts for 81.3% of the variations. The DVI is given as:

$$DVI = (0.792 \times PC_{DVI\,1}) + (0.208 \times PC_{DVI\,2}) \quad (7)$$

We repeat this process using the 10-year rolling volatility as a measure of robustness and results identify two components account for 85.2% of the variations (Table 6). The first component has a weight of 81.1% and the second component has a weight of 19.9%. The DVI is given as:

$$DVI = (0.811 \times PC_{DVI\,1}) + (0.199 \times PC_{DVI\,2}) \quad (8)$$

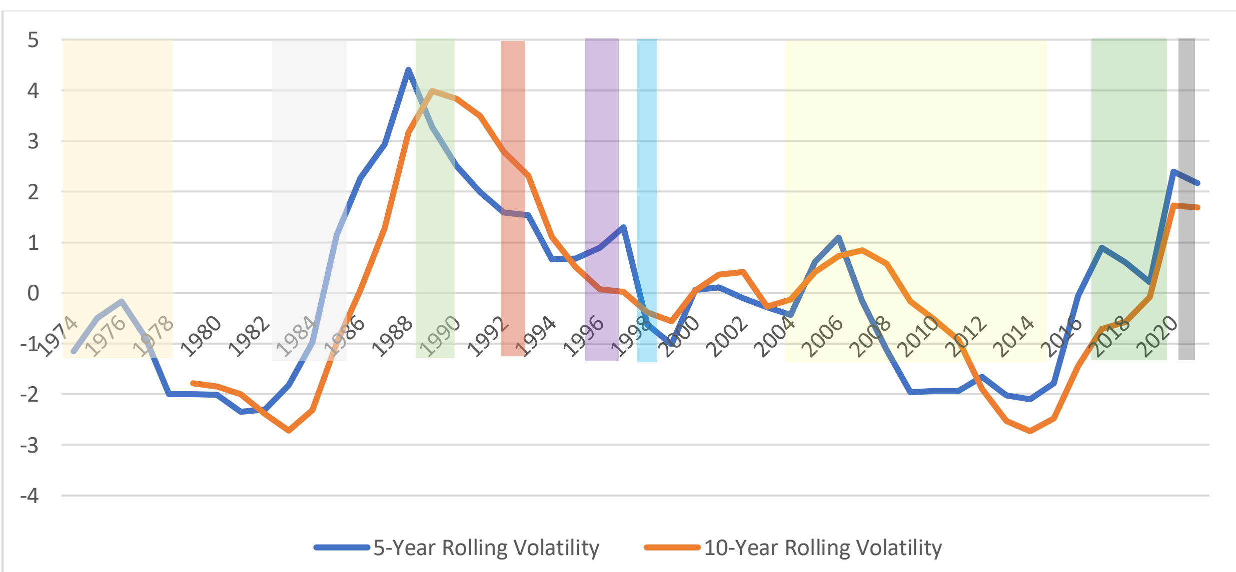
Table 6: Debt volatility index - PCA

PCA: 5-year rolling volatility				
Component	**Eigenvalue**	**Difference**	**Proportion**	**Cumulative variance**
1	4.5046	3.3212	0.6435	0.6435
2	1.1834	0.4147	0.1691	0.8126
3	0.7687	0.4172	0.1098	0.9224
4	0.3515	0.2501	0.0502	0.9726
5	0.1014	0.0259	0.0145	0.9871
6	0.0755	0.0604	0.0108	0.9979
7	0.0150	-	0.0021	1.0000
PCA: 10-year rolling volatility				
Component	**Eigenvalue**	**Difference**	**Proportion**	**Cumulative variance**
1	4.8378	3.7103	0.6911	0.6911
2	1.1276	0.3680	0.1611	0.8522
3	0.7596	0.5652	0.1085	0.9607
4	0.1944	0.1423	0.0278	0.9885
5	0.0520	0.0332	0.0074	0.9959
6	0.0188	0.0090	0.0027	0.9986
7	0.0099	-	0.0014	1.0000

Note: We use the Kaiser criterion which states that components with eigenvalues of at least one should be included within the index.

Like the DSI, the movements in the DVI in Figure 4 follow major events in the international oil markets as well as other national and global shocks. Consistent with the findings of Siddique et al. (2016) in their investigation of the impact of declining oil sales on HIPC countries in the 1980s, we find that the sharp rise in the DVI coincide with plummeting oil prices and domestic oil production between 1984 and 1989. This is especially so given Trinidad and Tobago’s high dependence on the energy sector which captures the positive correlation between current oil prices and current expenditure (see, e.g., El Anshasy & Bradley, 2012). The conditions are reversed between 1990 and 1994 which result in a fall in the DVI. In the study of 17 Latin American countries, Ames (1977) find that governments respond to the needs of the electoral cycles which increases public expenditure and Alesina et al. (1992) refer to a similar notion as political budget cycles. This results in rising debt, and from 1998 to 2008 we see volatility levels remaining low, but the changes are rapid which coincide with general elections in 2000, 2001, 2002 and 2007. El Anshasy & Bradley (2012) find that previous oil price volatility induces greater fiscal prudence especially when the exchange rate is fixed, and we see this in the DVI where volatility declines from 2008 to 2015 as high revenue from the energy sector result in a decline in deficit financing and the rate of debt accumulation. We also see history from the 1980s repeating itself from 2016 onwards, resulting in debt volatility increasing as deficit financing, and the higher cost of borrowing result in higher interest payments. Previous issues of debt instruments are due and rollover risks are present. Finally, we see a spike in volatility as the government requires short-term financing to fund stimulus packages to cushion the effects of the COVID-19 pandemic. This is the largest spike in volatility since the 1980s oil price war.

Figure 4: Debt volatility index (DVI)



Note: Refer to legend of Figure 3 and the main text for further details on annotated periods of historical global and country-specific significance.

6. Index implementation application: the debt-growth nexus

We continue by illustrating the applicability of our novel indices to investigate the debt-growth nexus in Trinidad and Tobago. Indeed, the empirical literature on the debt-growth nexus is quite infrequent (Checherita-Westphal & Rother, 2012) but its importance resurfaces after major shocks such as the global financial crisis or the COVID-19 pandemic as elevated debt reignites the cause for concern. A popular departure point for investigating the nexus between debt and economic growth is Reinhart & Rogoff (2010) who study this relationship in 20 advanced economies and 24 emerging market economies. Using simple correlation analysis on both groups of countries, they find that debt exceeding 90.0% (very high) results in lower growth. For emerging market economies with debt levels below 90.0%, median and average growth is approximately 4-4.5%. Despite the timeliness, relevance, and importance of their work, the scope is limited since it relies on correlation analysis and correlation does not imply causation. Additionally, they do not consider other determinants of growth.

Since then, authors such as Panizza & Presbitero (2014) and Kumar & Woo (2010) establish causal links between debt and growth by considering other determinants such as inflation, financial development, national savings, and gross capital formation to name a few. Consequently, the common issue of endogeneity is identified, and authors propose estimation techniques such as instrumental variable (IV) estimation with instruments such as lags of the debt indicator (see, e.g., Checherita-Westphal & Rother, 2012), foreign currency debt (see, e.g., Panizza & Presbitero, 2014) or lags of the regressors (see, e.g., Afonso & Jalles, 2013). In addition to addressing endogeneity, the instruments address reverse causation since low economic growth can induce greater debt burdens (Checherita-Westphal & Rother, 2012). Another key consideration since the work of Reinhart & Rogoff (2010) is the linear and non-linear relationships between debt and economic growth as countries' debt levels move between different threshold (see, e.g., Cordella et al., 2010; Égert, 2010).

A consensus in the empirical literature is the variables used to assess the debt-growth nexus. The primary indicator of economic growth is the change in real GDP per capita and as expected, debt-to-GDP is the debt indicator of choice. The consensus extends to regressors or control variables as well. These include the log of the initial GDP per capita (in levels or lagged), population growth, financial development, private savings, inflation, trade openness, unemployment, interest rate and gross fixed capital to name a few (see, e.g., Gómez-Puig et al., 2022). The most common estimation technique is IV estimation (see, e.g., Law et al., 2021 and references therein).

Yet, despite the harmony with methodologies and estimation techniques, estimated results remain diverse. For example, Panizza & Presbitero (2014) find no evidence of higher public debt adversely impacting economic growth across a sample of 17 OECD countries. Interestingly, their results differ from Cecchetti et al. (2011) in their study of 18 OCED countries as they take a multi-pronged approach to analysing the relationship between various forms of debt including government, corporation and household, and economic growth. They specifically find that when government debt exceeds 85.0%, it adversely affects growth. Checherita-Westphal & Rother (2012) find similar results in their investigation of 12 Euro area countries with debt thresholds of 90-100.0% but the threshold can be as low as 70.0% for individual countries. Below this threshold, additional debt can spur economic growth.

Cordella et al. (2010) takes a different perspective by including the quality of institutions and policies in their analysis of 79 developing countries. They find that in countries with good institutions and policies where debt rises above 20-25.0%, debt overhang is present and there is a negative relationship between debt and growth. However, the relationship disappears with very high levels of debt (about 70-80.0%). For countries with bad policies and institutions, the thresholds are much lower, but the relationship is insignificant. Law et al. (2021) undertakes a similar study of 71 developing countries and find a negative relationship between growth and debt when debt exceeds 51.7%. Below this threshold, however, the relationship disappears. Where developing countries have sound institutions above a threshold which can minimise or control the negative impact of rising debt, increasing debt can have a positive impact on growth. If institutions and policies are not sound, the relationship between debt and growth is negative above the 51.7% threshold but insignificant otherwise.

Adopting the work of Panizza & Presbitero (2014) and Law et al. (2021), we use annual growth in real GDP per capita to estimate the following:

$$g_t = \alpha + \beta \ln gdppc_t + \gamma d_t + \delta' X_t + \varepsilon_t \qquad (9)$$

where g_t is the percentage growth in real GDP per capita, $\ln gdppc_t$ is the natural logarithm of the initial GDP per capita, d_t is the measure of debt and X_t is the matrix of control variables including oil price, financial development, trade openness, inflation, unemployment, population growth and capital expenditure. We display the descriptions in Table A3 (Appendix).

Data for other common variables in the empirical literature such as the number of years schooling, gross capital formation, and national savings were not available for Trinidad and Tobago. Following Checherita-Westphal & Rother (2012), we instrument the measure of debt with its own lags, and we use three lags.

We do not adopt a threshold approach since debt-to-GDP averages less than 30.0% between 1970 and 2021. We show the baseline results using IV estimation in Table 7.

Table 7: Baseline economic growth regression estimates with novel country-specific debt regressors

Dependent variable: annual growth in GDP per capita	(1-DSI)	(2-DSI)	(3-DVI)	(4-DVI)
Log initial GDP per capita	19.953 (1.40)	52.568** (2.09)		
Log GDP per capita$_{t-1}$			-43.640*** (-2.99)	-77.646*** (-4.25)
Unemployment	0.158 (0.09)	0.811 (0.49)	-5.124*** (-2.92)	-5.153*** (-3.90)
Financial development	-0.214 (-0.29)	-0.832 (-1.32)	-1.033** (-2.13)	0.080 (0.16)
Inflation	2.578* (1.86)	3.37** (2.20)	-0.923 (-1.02)	-1.497 (-1.61)
Trade openness	0.716*** (3.68)	0.853*** (4.22)	-0.195 (-0.65)	-0.409 (-1.48)
Population growth	4.384 (1.17)	5.677* (1.75)	0.258 (0.05)	-0.282 (-0.08)
Capital expenditure	-0.001 (-3.8)	-0.000 (-0.09)	0.003* (1.67)	0.002* (1.81)
Country specific debt index	8.537** (2.05)	10.032*** (3.04)	4.395* (1.91)	2.703** (2.02)
Oil price		-0.680* (-1.91)		0.920*** (3.78)
Constant	-248.361 (-1.45)	-518.297** (-2.05)	506.184*** (2.98)	757.903*** (4.25)
N	48	49	45	45
$R - squared$	0.19	0.216	0.334	0.561
Hansen J p-value	0.535	0.934	0.744	0.930
Kleibergen-Paap rk LM statistic p-value	0.082	0.009	0.00	0.001
Kleibergen-Paap rk Wald F statistic	11.346	19.997	22.874	24.614

Note: The estimates from columns 1 and 2 correspond, respectively, to the DSI model specification excluding and including oil price. The estimates from columns 3 and 4 correspond, respectively, to the DVI model specification excluding and including oil price. We instrument the debt variable with three lags of itself. For each estimate, we report the number of observations and the centred R-squared and the results from the instrument diagnostics. For the overidentification test, we report the p-value of the Hansen J statistic. The null assumption is that the overidentifying restrictions are valid. We report the p-value for the Kleibergen-Paap rk LM statistic where the null assumption is that the model is underidentified. We also report the Kleibergen-Paap rk Wald F statistic which exceeds the Stock & Yogo (2005) critical value with 10% maximal IV relative bias where the null assumption is weak identification. T-statistics are in parentheses, * denotes statistical significance at the 10% significance level, ** denotes statistical significance at the 5% significance level, *** denotes statistical significance at the 1% significance level.

We start with the baseline specification which assesses the debt-growth nexus using the DSI and DVI and we illustrate the results in Table 8. For robustness, we compare the estimates with and without oil price given its significance to the economy. In column 1, the estimates suggest a positive and significant relationship between the DSI and economic growth. This is consistent with the findings of Cordella et al. (2010) and Law et al. (2021) in their analysis of developing countries. With historically low levels of debt over the last 50 years which averages less than 30.0%, incurring additional debt favourably impacts growth. The results are consistent when we include oil price, but the complicated relationship between oil price and growth reappears capturing a negative relationship between oil price and economic growth. However, this is plausible in Trinidad and Tobago since this country is regarded as a welfare state and prosperity from the energy sector translates into increase spending on subsidies and transfer payments, with a significantly lesser proportion of the prosperity allocated to capital expenditure and other growth-related activities.

The resource curse, which characterises the paradoxical inability of natural resource-rich countries to grow in line with their resource poor-counterparts (see, *inter alia*, Sachs & Warner, 2001), is not an infrequent finding in the empirical literature as booming oil prices can negatively impact growth. Manzano & Rigobon (2001) argue that debt overhang is a plausible channel of the resource curse, as resource-rich developing countries who use high commodity prices as collateral for debt tend to experience debt crises when such international prices collapse. As future increases in commodity prices are likely used to service debt and related fiscal expenses rather than contribute to economic growth, it becomes plausible to establish a negative link between booming oil prices and growth. Inflation and trade openness are also statistically significant. The estimation satisfies all instrument diagnostics.

Since the DVI captures rolling volatility, we analyse the debt-growth nexus by parsimoniously including the lagged initial GDP per capita as adopted from Law et al. (2021). The estimation satisfies all diagnostics, and we find a positive and statistically significant relationship between the DVI and growth. This is intuitively true for Trinidad and Tobago since we only see two sharp increases in the DVI over the 5 decades of economic history. Otherwise, volatility remain fairly low to moderate. Looking closer, an increase in volatility is usually as a result of a decline in the repayment capacity of debt, for example, revenue, GDP, and energy exports. If the fall in revenue is accompanied by a similar fall in expenditure, it can be detrimental to growth. However, with government's recurrent and welfare expenditure remaining sticky, it can favourably impact growth. This is consistent with the findings of Afonso & Furceri (2010) in their investigation of the size and volatility of revenue and expenditure across OCED and EU countries. With the DVI, oil price positively impacts growth. This can be due to the DVI already capturing the volatility of revenue and energy exports. Capital expenditure and unemployment are also statistically significant.

Table 8: Robustness analysis – alternative specifications of economic growth regression estimates with the traditional single metric debt-to-GDP ratio

Dependent variable: annual growth in GDP per capita										
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
Log GDP per capita$_{t-1}$	-8.265**	-24.996***	-19.466	-27.938**	-33.802***	-28.713***	-41.466***	-40.625**	-53.406***	-56.490***
	(-2.47)	(-3.04)	(-1.64)	(-2.22)	(-2.71)	(-4.09)	(-4.15)	(-2.34)	(-3.70)	(-3.88)
Debt-to-GDP	-0.269	0.130	0.165	-0.013	0.099	0.088	0.405	0.413	0.218	0.2946
	(-1.19)	(0.49)	(0.53)	(-0.04)	(0.27)	(0.37)	(1.52)	(1.52)	(0.74)	(0.92)
Unemploy-ment		-2.889***	-2.234*	-3.066**	-3.506***		-2.487***	-2.416*	-3.477***	-3.774***
		(-3.04)	(-1.73)	(-2.31)	(-2.68)		(-3.08)	(-1.75)	(-2.91)	(-3.15)
Trade openness			0.144	-0.064	-0.126			0.020	-0.252	-0.285
			(0.50	(-0.20)	(-0.40)			(0.07)	(-0.81)	(-0.92)
Population growth				-4.259***	-4.488***				-5.325***	-5.415***
				(-2.63)	(-2.60)				(-2.84)	(-2.72)
Capital expenditure					0.002					0.002
					(1.28)					(1.26)
Oil price						0.724***	0.665***	0.658***	0.726***	0.697***
						(3.76)	(4.44)	(-2.34)	(5.30)	(4.63)
Constant	88.815***	256.833***	187.331	297.338*	354.074**	229.901***	363.092***	353.243*	507.899***	538.763***
	(2.81)	(3.55)	(1.29)	(1.86)	(2.25)	(4.44)	(4.19)	(1.90)	(3.00)	(3.21)
N	49	49	49	49	49	49	49	49	49	49
$R-squared$	0.169	0.322	0.336	0.393	0.419	0.359	0.461	0.461	0.554	0.563
Hansen J p-value	0.436	0.329	0.331	0.752	0.485	0.302	0.305	0.187	0.346	0.739
Kleibergen-Paap rk LM statistic p-value	0.000	0.002	0.002	0.009	0.010	0.002	0.010	0.008	0.018	0.016
Kleibergen-Paap rk Wald F statistic	20.893	20.316	19.439	12.731	10.569	15.528	15.704	16.476	11.542	9.705

Note: The estimates from columns 1 to 5 correspond, respectively, to the model specification with the debt-to-GDP ratio and the progressive inclusion of regressors and excluding oil price. The estimates from columns 6 to 10 correspond, respectively, to the model specification with the debt-to-GDP ratio and the progressive inclusion of regressors and including oil price. Refer to all other notes from Table 7.

For robustness, we repeat our investigation of the debt-growth nexus using the debt-to-GDP ratio as our measure of government debt along with other control variables that we parsimoniously select, and we illustrate the results in Table 8. We find that in all specifications except column 1, the coefficient of debt is positive but statistically insignificant. The positive impact of debt on growth is consistent with the findings of our DSI and DVI. Our novel country-specific indices are statistically significant as it more comprehensively captures government indebtedness when compared to debt-to-GDP. We find that the relationship between oil price and growth is positive and statistically significant. This is consistent with the findings of Berument et al. (2010) in the investigation of MENA countries such as Iran, Kuwait, Qatar, and the United Arab Emirates. Interestingly, we see that oil price is a confounding variable since it was negative in the baseline specification with the DSI. We attribute this to the fact that the DSI comprehensively captures oil prices and by extension the energy sector with the external debt to energy exports indicator, and its interaction with oil price in the baseline DSI specification results in a negative impact on growth. However, the alternative specification does not have such interaction. Population growth is negative and statistically significant across all specifications, and this is consistent with theory and the empirical findings of Law et al. (2021) and Pattillo et al. (2002). The coefficient of unemployment follows in a similar vein and all model diagnostics are satisfied.

7. Conclusion

While we recognise the merits of debt-to-GDP as an indicator of government debt, we argue that the drawbacks as the sole indicator of government indebtedness outweigh the benefits of its simplicity and comparability over time and across countries. We critically assess both the measure of indebtedness (debt) and the repayment capacity (GDP) and identify its limitations. Given the importance of debt sustainability to overall economic performance and stability, we propose and develop a novel debt sustainability index (DSI) and its companion debt volatility index (DVI) to better assess the fiscal health of the country.

Using the OECD (2008) methodology and principal component analysis (PCA), we construct the DSI and DVI using seven globally recognised indicators of government indebtedness. We posit that these indices are superior to debt-to-GDP since it combines various indicators of government debt including interest payments as well as different repayment capacities such as exports and government revenue so it can better help policymakers understand the true state of government debt. The index can serve as an early warning system by analysing the DSI in conjunction with the DVI that signals the cyclical patterns of volatility including national elections, debt maturity and rollovers, and principal and interest repayments. It can also aid public accountability and credibility as many components of debt may be hidden and a simple index makes it easier to understand the true fiscal and debt position instead of being bombarded by multiple indicators.

Finally, and most importantly, the DSI and DVI can be used to assess debt sustainability from perspectives that cannot be examined by debt-to-GDP only. They can be used within the Bohn (1998) fiscal reaction function to assess sustainability by examining fiscal policy response to changes in the DSI and DVI. It can also be used in generating forecasts and debt trajectories and debt reduction pathways through stochastic simulations. We construct the DSI and DVI for Trinidad and Tobago, but its applicability extends to any developing economy and small states as the variables are likely to be readily available. The reliability of our index is supported by the simultaneity of pronounced movements in the DSI and DVI with remarkable historical events that impact Trinidad and Tobago, the source of which originates from global energy market shocks. The reliability and use of our index is further reinforced through its application in assessing the debt-growth nexus for Trinidad and Tobago. We find that the baseline specification using our indices produce robust and significant results when compared to alternative specifications using the debt-to-GDP ratio. With these indices, users can analyse and examine the true level of government debt, the progress made towards moving debt to sustainable levels, its relationship with key macroeconomic performance indicators such as growth, and the expected volatility that may arise should adverse shocks occur.

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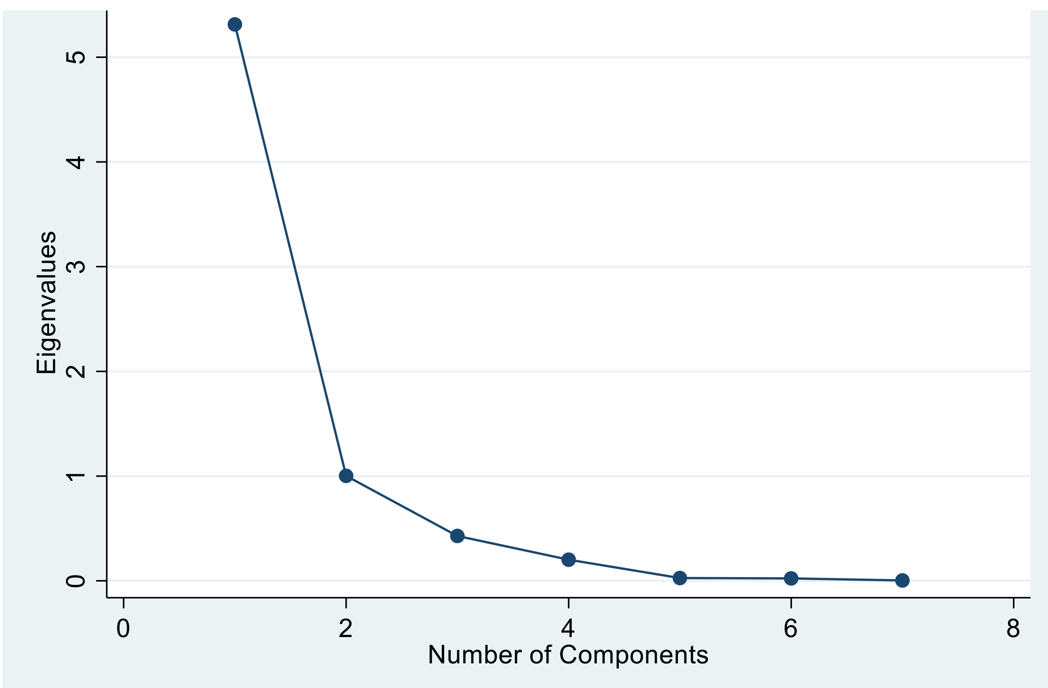
Appendix

A1: Scree Plot – debt sustainability index



A2: ARCH LM test

Lags/df	DTR	DTX	DTG	ITR	EDEE	EDE	EDRES
1	0.168	13.502*	7.086*	0.911	4.005*	3.090	5.852*
2	0.427	13.878*	6.813*	0.790	3.955	2.983	7.663*
3	0.501	13.595*	6.720	0.970	3.995	4.471	7.530
4	2.650	16.968*	10.023*	2.017	4.006	4.481	7.571
5	2.754	17.014*	13.294*	2.133	8.631	7.436	7.712

Note: * denotes the presence of ARCH effects at 5% significance level, where df refers to degrees of freedom.

A3: Variables and descriptions for the debt-growth nexus model

Variable	**Description**	**Source**
Real GDP per capita	Real GDP divided by the population.	Central Bank of Trinidad and Tobago.
Trade openness	The sum of exports and imports, expressed as a per cent of nominal GDP.	Central Bank of Trinidad and Tobago and author's calculation.
Financial development	The ratio of private sector credit as a per cent of nominal GDP.	Central Bank of Trinidad and Tobago and author's calculation.
Inflation	The year-on-year per cent change in the Index of Retail Prices for all items with a base year of 2015.	Central Bank of Trinidad and Tobago.
Oil price	The price of crude oil (measured in US$ per barrel) as priced by West Texas Intermediate (WTI).	Central Bank of Trinidad and Tobago and Statista.
Population growth	The annual percentage growth in the population.	Central Bank of Trinidad and Tobago and author's calculation.
Unemployment	The number of unemployed persons as a percent of the labour force.	Central Bank of Trinidad and Tobago.
Capital expenditure	Annual capital expenditure as a percent of nominal GDP.	Central Bank of Trinidad and Tobago and author's calculation.