

# **PUBLIC DEBT SUSTAINABILITY ANALYSIS**

## **AN EMPIRICAL APPROACH FOR BRICS NATIONS**

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## **1. Abstract**

This paper carries out an empirical test for public debt sustainability in the BRICS nations. This work is part of an important literature on fiscal reaction functions and focuses on the response of primary balances to past public debt. Part of a novelty contribution is the inclusion of natural disaster and political variables in the analysis. The paper utilizes a balanced panel with the 5 BRICS nations over 20 years and performs both fixed effects and random effects (feasible GLS) estimations. The main findings are: (i) BRICS nations public debt seems not sustainable, which requires specific attention and close analysis from policymakers, and (ii) even though the cost of natural disasters seems to not have a significant effect, several political variables do have an effect on the country's primary balance, as supported by most of the existing literature. The paper acknowledges the need for further research on this topic, given its relevance in today's economic context of rising interest rates.

## **2. Introduction**

According to the International Monetary Fund (IMF), Public Debt can be defined as the whole stock of obligations assumed by a government with fixed-term contractual obligations at a certain period of time. Public debt can be domestic or external and comprises a big variety of instruments like money deposits and currency, securities, loans etc. It can be analyzed by creditor, maturity, instrument but its most important aspect is that it represents how governments are funding investment or even a fiscal disequilibrium. For that reason, studying and understanding public debt's trajectory is crucial to have a diagnosis on a country's fiscal health and economic robustness. Additionally, good debt management can prevent the indebtedness level from hurting economic growth and fiscal stability.

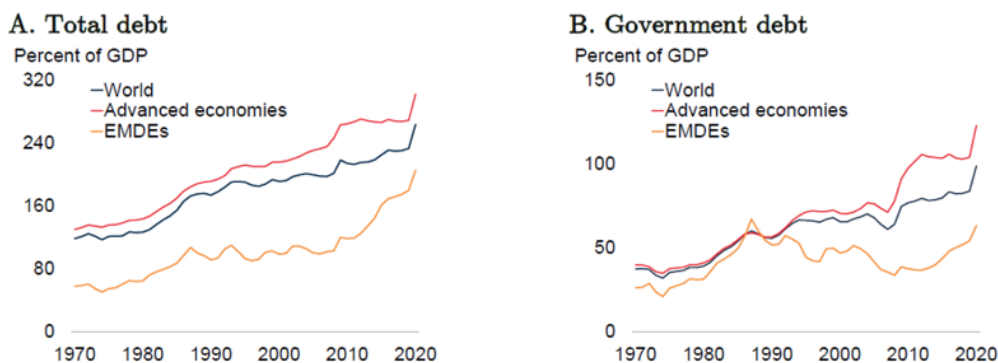
Public Debt is considered sustainable, in broad terms, when a country can honor both in the short and long run, all its creditor's claims and financial obligations without any need of financial assistance or going into default. From a conceptual point of view, sustainability of public debt can be guaranteed as long as the government upholds its intertemporal budget constraints.

The accumulation of public debt has accelerated, especially in recent years, due to a sizeable fiscal expansion as a response to the COVID-19 pandemic, forcing governments to expand public

spending beyond their budgetary limits. According to (Kose, Nagle, Ohnsorge, & Sugawara, 2021), the largest debt buildup (public and private) in many decades, is being observed now. The authors mention as examples: the 1970s and 1980 governments' debt expansion in Latin America and Low-Income Countries and the crisis and default episodes following; the 1990s and early 2000s in East Asia and Pacific (EAP) with serial economic crisis between 1997-2001; and the Europe and Central Asia (ECA) wave of debt accumulation that resulted in the 2008 crisis. Attention is called to the fact that in 2020 total global debt achieved 263% of GDP, an increase of 30 percentage points, the largest single-year increase since 1970.

The figures below show the evolution of total debt and government debt for the global economy, advanced economies and emerging markets and developing economies since the 1970s:

#### Debt developments during Covid



Source: World Bank

**Figure 1**

In this context, as stressed by the IMF, “Public debt as a ratio of GDP soared across the world during COVID-19 and is expected to remain elevated, posing a growing challenge for policymakers, particularly as interest rates are rising across the world” (International Monetary Fund, 2023).

Amid such economic reality, we focus on the analysis of BRICS nations (Brazil, Russia, India, China and South Africa) and the sustainability of their public debt. These countries represent approximately 31% of the world's GDP per capita in PPP (up from 18% back in 2000), and account for 40% of the global population. More specifically, these countries are among the most relevant

within emerging markets and developing economies, and also happen to show one of the largest debt accumulations in the past years.

Natural disasters have caused societal, financial, cultural, and welfare distress across the world, in economies big and small. With the worsening of the climate change crisis and global warming, natural disasters such as floods, droughts, extreme temperatures, storms etc. are only increasing in number. The Global Assessment Report on Disaster Risk Reduction (United Nations Office for Disaster Risk Reduction, 2022) stated that the estimated average losses from tsunamis, earthquakes, tropical cyclones, river flooding, and other disasters, were approximately US\$170 billion per year over the last ten years. The burden of these damages is mostly borne by governments as they are the most efficient providers of assistance and it is their moral obligation, thus directly impacting central government's debt behavior. It impacts debt by increasing amounts owed, as well as damaging channels of productivity and sources of revenue which are used for debt payments. Thus, it is important to consider the role played by frequency and cost of natural disasters when assessing a country or region's debt sustainability.

Furthermore, historically, institutions all over the world have identified the close relationship between politics and economics, be that the last king of the Maurya empire in India – Dhana Nanda, who lost the throne because of Chanakya's observation of the king's heinously high taxation rates (Aiyah & Sastri, 1988); or the Reagan presidency, for being known to have rekindled the US economy from the brink of a depression.

Global institutions have long been endeavoring to ascertain and solidify the impact of political stability on economic growth. It is estimated that terrorism and the absence of stability has cost the world economy almost US\$ 855 Billion in the period between 2010 to 2018 (Bardwell & Iqbal, 2020). As the world moves forward to a transparent, digital haven, and nations begin to embrace new identities forged in the aftermath of the pandemic, it becomes increasingly important to begin re-evaluating the politics and institutions of the past from an economic lens. Utilizing the myriad of political perspectives at our disposal allows us to understand primary balances from the outlook of a leader, and how being politically gifted, translated – quite evidently- into being economically sound.

This paper, therefore, empirically analyses public debt and sustainability from the crises, climate change and political stability outlooks.

### 3. Literature Review

#### 3.1. Theoretical Underpinnings of Public Debt Sustainability

The theoretical frameworks under which public debt sustainability has been analyzed have evolved during the past decades. On the one hand, the accounting-based approach for public debt sustainability requires an understanding of the intertemporal government budget constraint (IGBC) and the associated debt dynamics. (Willems & Zettlemeyer, 2022) provide insights on such analysis, and note that: (i) when solving the government budget constraint equation for the debt-to-GDP ratio, the result states that today's debt must equal the discounted terminal debt plus the discounted present value of primary balances (notably, surpluses) on the analyzed horizon, and (ii) "there are two ways of operationalizing the broad, quantitative definitions of policy and debt sustainability", one is the classic version in which the IGBC must hold, which requires no-Ponzi schemes, and the other is one that requires that current and projected future policies do not lead to an exploding debt ratio. As the authors mention, a context in which, at least on average, the government real borrowing rates are higher than the country's real growth rate ( $r > g$ ) is deemed relevant under this classical approach .

In contrast to the classical approach to public debt sustainability, (Blanchard, 2019) explores the context of low interest rates and public debt. The lecture focuses on the welfare costs of higher public debt in specific contexts of interest rate and growth, with a concrete mention to the relevant dynamics between the safe rate and the marginal product in the overall welfare of the economy. In addition, he shows that for the US the environment of safe rates that remain below growth rates (arguably,  $r < g$ ) is more the norm than the exception. Under such context, and to the provocation of many economists, with  $r < g$  on average "*higher debt might not imply fiscal costs*". It should be noted that (Blanchard, 2019) does not claim that this environment does not make any fiscal policy sustainable.

Lastly, recent work from (Reis, 2022) explores the concept of Debt Revenue as an alternative to the traditional public debt sustainability analysis framework. In the author's words, "*Since, for some reason, people are willing to hold public debt in spite of it giving a lower return than the private market alternative, their opportunity cost of doing so is a form of revenue for the government. Supplying public debt is providing some service to these investors. (...)*." The introduction of the marginal product of capital changes the typical budget constraint, and the result

is an additional term which accounts for these ‘premiums’ between the marginal product of capital and the return of government bonds. Importantly, the results from (Reis, 2022) do acknowledge some difficulty on measuring the marginal product of capital and proves alternative approaches, but it notes the need to consider the Debt Revenue dynamics for policymakers given its implications for public debt sustainability analysis.

### ***3.2. Empirical Debt Sustainability Tests***

The most important paper in terms of content and academic basis to this research is *The Behavior of U.S. Public Debt and Deficits* (Bohn, 1998). Bohn’s idea was to investigate how governments react to expansion of debt and he used U.S. data from 1916-1995 in his analysis of how responsive the fiscal results were to a debt accumulation process. The author criticizes the stationarity tests and co-integration tests used so far to measure public debt governance and proposes a new test on debt sustainability. Through his study, the author shows that U.S. presents a mean-reverting tendency and the tests adopted in the previous literature for debt sustainability fail to reveal omitted variables bias and provide unreliable estimates.

This test states that public debt is sustainable if the noninterest budget surplus/GDP is a positive function of the debt–GDP ratio. The economic intuition behind this regression is that if we have a scenario in which the level of debt is increasing, the government will react by aiming for a positive or higher primary result to avoid any fiscal imbalance which can turn the debt management into an uncontrollable situation. One interesting aspect of this sustainability test is that it does not require any interest rate assumptions.

Following the work from Bohn, a wide application in terms of time periods and regions has been made. This is part of the growing literature regarding the Fiscal Reaction Function (FRF). Among many we can mention *Debt sustainability and the fiscal reaction function: evidence from MIST countries* (Ogbeifun & Shobande, 2020) in which the authors analyzed the relationship between primary balance in MIST countries (Mexico, Indonesia, South Korea, and Turkey) and public debt using a panel dataset from 1990 through 2017 to explore how sustainable fiscal policy in those economies were. In their fixed-effect regression and feasible generalized least squares estimations models they included primary balance as a dependent variable, lagged of debt-to-GDP ratio as the independent variable, interest payment on the public debt, current account balance, a business cycle variable- derived from the GDP series, an election year dummy and lagged primary balance

as additional control variables. They observed that in MIST countries, “*primary balance improves by about 0.005–0.013 for every 1 percentage point increase in central government debt after controlling for other relevant factors*”. The study concluded with a recommendation to increase tax base revenue and reduce fiscal expenditure across MIST (Ogbeifun & Shobande, 2020).

Another research work that influenced our choice for the fiscal reaction function was an empirical analysis of sustainability of public debt among BRICS nations (Joy & Panda, 2020) that besides developing a version of the FRF also investigated this relationship among BRICS economies during the years 1980–2017. Their model estimated the impact of variables like dummies of election year, ideology of the government and unemployment on primary surplus. Furthermore, a structural change dummy was included to measure how debt progression is affected by the 2008 financial crisis. With the result being a positive, albeit small, significant coefficient, it was observed that the primary balance for BRICS improves when the debt to GDP ratio increases in the region as a whole. “*This suggests that though the public debt is sustainable for BRICS, it is not strong enough. Small size of coefficient means sustainability is negligible. China and India have better public debt sustainability levels compared to Brazil, Russia, and South Africa.*” (Joy & Panda, 2020). When unemployment rises in BRICS the fiscal reaction is weakened, diminishing the response of primary balance to increase in debt, especially after the 2008 crisis. Regarding the political variables, it was noticeable that “*election year is negatively affecting sustainability since during election years governments take more liberal public spending and populist measures by using borrowed fund*” (Joy & Panda, 2020). Governments with weak coalitions tended to present less effective fiscal reactions and those who presented a more “centrist” political ideology showed a positive coefficient, even though it was not statistically significant, giving evidence that a more balanced power structure enables better fiscal management.

### **3.3. Public Debt Dynamics**

An initial consideration to have regarding public debt and its sustainability is understanding public debt dynamics. On one hand, as mentioned previously, one can infer the evolution of public debt (and its sustainability) directly from an inspection of the government budget constraint for a specific period. On the other hand, on a more comprehensive framework, public debt dynamics can be analyzed as a decomposition of changes in public debt in response to more interesting underlying macroeconomic factors. Unfortunately, there is no clear formula that allows a clean

additive decomposition of changes in the debt ratio into the most interesting underlying factors, such as interest rates, inflation, fiscal adjustments, etc. (Escolano, 2010). Nonetheless, the IMF does provide guidance on the Sovereign Risk and Debt Sustainability Framework (SRDSF) for market access countries<sup>1</sup> which can be helpful to understand the evolution of public debt as a reflection of movements in key macroeconomic variables (drivers), along with the inclusion of realism tools to evaluate the realism of baseline economic forecasts, as well as near-term, medium-term, and long-term risk assessments tools. Following the IMF (International Monetary Fund, 2022), public debt in one year can be related to the previous year's debt, the interest bill, the primary balance, and other factors in stock-flow adjustment (see appendix A).

Importantly, from this analysis we can find an expression for the debt-stabilizing primary balance (assuming no changes in public debt, as well as no stock-flow adjustments and other potential transformations to the equation). From an empirical point of view, this enables a tool to discuss public debt sustainability on the basis of macroeconomic variables, as well as other variables of interest which could affect the 'stock-flow' adjustments.

### **3.4. Public Debt and Crises**

The mention of public debt dynamics is key to understanding the more concrete and broadly studied topics of public debt, sovereign default, and economic crises. One of the most prominent pieces of work on this topic is that carried out by Carmen Reinhart and Kenneth Rogoff in their book *'This time is different: Eight Centuries of Financial Folly'*. In their words "*This book provides a quantitative history of financial crises in their various guises. Our basic message is simple: We have been here before. (...), we study a number of different types of financial crises. They include sovereign default, which occur when a government fails to meet payments on its external or domestic debt obligations or both.*" (Reinhart & Rogoff, *This time is different: Eight Centuries of Financial Folly*, 2009).

For the current paper's purpose, we look at similar work from the authors which analyzes the dynamics between external debt, banking crises and public debt surges. Among other important findings, the authors note that: (i) "*domestic banking crises help to explain sovereign default,*" and (ii) "*surges in public debt have the expected significant positive effect on the likelihood of default*"

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<sup>1</sup> The IMF and the World Bank also provide an analytical framework for Low Income Countries (LIC) in the LIC-DSF.



(Reinhart & Rogoff, From Financial Crash to Debt Crises, 2011). These results support the need to preemptively analyze the dynamics of public debt in countries across the world in the context where potential crises could unfold. In addition, the de-facto default on sovereign debt is also deeply related to public debt sustainability: for the intertemporal government budget constraint to hold, either expected primary balances are required to adapt to sustain a specific public debt level, or the existing public debt level must decrease, which implies the occurrence of sovereign default.

In addition to the literature studying the relationship between public debt and crisis, there is vast literature that analyses the determinants of sovereign default. One of the objectives of this literature is to identify a series of early warning indicators that can be used to predict default episodes (Panizza, Sturzenegger, & Zettlemeyer, 2012). For instance, (Ghulam & Derber, 2018) describe research by (Manasse & Roubini, 2009) in which they “*use a classification and regression tree (CART) methodology on a panel dataset including 47 market economies from 1970 to 2002*”. (Manasse & Roubini, 2009) find ten variables as sufficient for the classification or prediction of sovereign default: (i) external debt to GDP ratio, (ii) short-term debt reserves ratio, (iii) real GDP growth, (iv) public external debt/fiscal revenues ratio, (v) CPI inflation, (vi) number of years to the next presidential election, (vii) US treasury bills rate, (viii) external financial requirements, which consists of current account balance plus short term debt as a ratio of foreign reserves, (ix) exchange rate overvaluation, and (x) exchange rate volatility. This framework of analyzing sovereign default as a binary event that responds to macroeconomic factor mirrors that of analyzing public debt dynamics, and therefore is directly linked to public debt sustainability. Lastly, on a related note (Martinez, Roch, Roldan, & Zettlemeyer, 2022) survey the literature on sovereign debt from the perspective of understanding how sovereign debt differs from privately issued debt, and why sovereign debt is deemed safe in some countries but risky in others.

### ***3.5. Political Sustainability and Public Debt***

The interplay between political stability and public debt is one that is explored quite well in several papers, both by global peacekeeping and economic organizations such as the International Monetary Fund or the World Bank, but also by think tanks and educational institutions such as the Brookings Institute. (Kaufman, 2010), finds a strong negative relationship between Corruption and public finance in industrialized countries, identifying several channels including reducing tax

revenues, raising government expenditure, and worsening the financial sector's risk, among others. The IMF defines corruption as the abuse of public office for private gain (Lagarde, 2017).

(Cooray, Dzhumashev, & Schneider, 2017), find that corruption plays a statistically significant role in worsening the public debt ratio in their sample of 126 countries, which includes both developing and industrialized nations. They also find that the effect of a larger shadow economy magnifies the effect of corruption on public debt, by reducing tax revenues. The analysis in this avenue of research draws a conclusive and substantial link between high corruption rates and economically harmful fiscal balances. Corruption has been found to reduce growth (Mauro P. , 2000) (Tanzi, 2002), discourage investment (Campos, Lien, & Pradhan, 1999) (Mauro P. , 1995) (Brunetti, Kisunko, & Weder, 1998); reduce foreign direct investment (Wei, 2000); and limit productivity (Lambsdorff, 2003).

However, it is worth noting that some literature also indicates that corruption might have a positive role in the economy. (Leff, 1964) suggests that the existence of corruption may be responsible for the removal of cumbersome bureaucratic requirements and can be beneficial for economic growth. Most of the studies that support the notion of corruption in an economy suggest that the effect of the growth on corruption strongly depends on the institutional environment of that economy (Aidt, 2009; Dzhumashev, 2014; Shleifer & Vishny, 1993; Rosa, D., & Görg, 2010; Meon P. &, 2005; Meon P. &, 2010) Perhaps most importantly in this segment, a paper by (Dzhumashev, 2014), shows that the interaction between corruption and governance shapes the efficiency of public spending, which in turn determines the growth effects of corruption. This paper will aim to utilize the variable – *Control of Corruption* from the world development indicators, to estimate the impact of corruption on primary balance.

The second variable we aim to consider is *Political Stability and the Absence of Violence/Terrorism*. (Aisen & Jose Veiga, 2010), define political instability as a serious malaise that is harmful to economic performance. One channel of effect on macroeconomic variables is that political instability shortens the policymaker's time in office, leading to suboptimal, short-term macro-focused policies. It may also create unnecessary volatility through frequent switching of policies. When we consider the absence of violence as a variable, one potential channel that is explored is how the absence of violence and terrorism reduces the government's need to focus its budget on peace-keeping activities. This, therefore, suggests the presence of a direct relationship

between political stability and primary balance. Several papers explore the link between economic growth and terrorism. Bardwell (Bardwell & Iqbal, 2020) estimates the impact of terrorism from the year 2000 to 2018 to be approximately US\$ 855 Billion to the world economy. (Elnahass, Marie, & Elgammal, 2022) suggest that there is a high correlation between political stability and banking stability as well, implying that political conflict affects the economy at its most fundamental level. (Compaoré Ali, 2020), find that the effect of violence and political stability can be geographically pervasive as it affects the economic growth and fiscal balances of neighboring countries. In other work of this nature, an empirical link has been drawn between poor long-run economic growth and political instability, in a sample of 169 countries, from 1960-2004 (Aisen & Jose Veiga, 2010).

Another field that this paper is interested in exploring is the link between a *Government's Effectiveness* and the primary balances of an economy. There is a logical direction of thought which suggests that the more effective a government is, the more effective its channels of spending are, and the less it requires for a certain level of welfare effects as compared to an economy with poor effectiveness. Furthermore, effective governments are marked by fewer bureaucratic and administrative obstructions, which facilitate economic activity and improve the primary balance by decreasing wasteful and grandiloquent spending. One paper empirically analyses 21 OECD countries from 1981-2008, and their primary balances, from an institutional perspective, and states that a government consolidation program aimed at reducing debt will have enhanced long-term effects, if the government is effective. However, this paper also suggests that the reduction in spending has a stronger effect on the reduction in primary balances, only after considering what the spending comprised of (F, A, & T, 2013). (Afonso & J, 2022) reinforce this idea by noting in their panel cointegration study of 19 Eurozone countries from 1995-2020, that they find a strongly significant negative correlation between the Effectiveness of a government and the primary balance (measured by the reduction public debt to GDP ratio).

The final political variable that we will consider is *Regulatory Quality*, and its effect on the public debt of an economy. (Musa, Sohag, Said, Ghapar, & Ali, 2023), in their study of developing economies from 1990-2000 find that strong regulations (measured as 'good governance') improve the relationship between public debt and economic growth, meaning, even though the public debt is high, economic growth is impacted positively through it. Essentially implying that strong

regulations improve the way the debt accumulated by the government is utilized well. Furthermore, they find that if the regulations are too strong, they begin to hinder growth by introducing bureaucratic and administrative impediments. In their respective empirical analyses, (Law, Ng, Kutan, & Law, 2021) and (Appiah-Kubi, et al., 2022) explore and successfully validate the hypothesis that poor governance is the main reason for the failure of public debt.

One key limitation of this research is that it is region focused. Most of the gathered dataset includes countries from the OECD regions, the Eurozone regions, or African/Sub-Saharan African regions. This primarily implies that the dataset includes developed nations that are more commonly associated with improved perceptions of political variables. For instance, there is a direct correlation between the economic status of the country and Political Variables. This paper overcomes this limitation by looking at the BRICS nations, a region-independent collection of nations with a similar economic trajectory or outlook.

Another limitation of the prevailing literature is its close reliance on a few factors of consideration. For instance, certain papers focus only on the political variables, like in the case of (Çam & Özer, 2022); whereas others focus only on macroeconomic factors, restricting themselves to the relevant political variable of interest such as (Tarek & Ahmed, 2017).

Our paper overcomes this limitation by being region independent, and, incorporating all sides of the spectrum – crises, macroeconomic, and political variables extensively, whilst also introducing a necessary and relatively underrecognized phenomenon – the impact of climate change - on the primary balances.

### ***3.6. Natural Disasters/ Climate Change and Debt Sustainability***

Prior research on the impact of natural disasters on macroeconomic factors such as debt has primarily focused on Caribbean countries given their higher likelihood of experiencing extreme weather events such as storms, cyclones, tsunamis etc. Most studies have displayed a negative consequence of disasters on economic parameters. (Acevedo, 2014) employed a panel Vector Auto-Regression (VAR) model to find that storms and floods lead to a drop in growth and output. Additionally, it was found that storms do not lead to an increase in debt, but floods do. Storms often receive more aid when compared to floods, and hence the reduced debt burden during storms. (Koetsier, 2017) finds that natural disasters and climate change events increase not just present

debt but also future debt. They observed an average treatment effect where government debt was 23 to 37 percentage points higher in the disaster group than the synthetic control group over short- and long-term periods. This effect persisted for at least 10 years after the disaster. The disparity of the debt levels between the control and treatment group only grew over time.

However, there has been contrary evidence as well, where (Skidmore & Toya, 2002) found that rebuilding the lost capital stock post-disaster, results in growth of output in the reconstruction phase. It was argued that the contradictory nature of the evidence was resolved when the size of the disaster was taken into account. (Cavallo, Galiani, Noy, & Pantano, 2013) found that only when a disaster was extremely large did it have a negative impact on output in both the long and short run. They further found that if controlled for radical political revolutions post-disaster, the negative impact of extremely large disasters on economic growth disappears.

This study aims at assessing the impact of the cost of natural disasters on the sustainability of public debt in the BRICS nations. Prior studies (for eg. (Koetsier, 2017)) have used the occurrence of a disaster (size determined by number of deaths caused by disaster), however this paper aims to use the cost of damages as it is felt to be a more direct factor influencing debt and debt sustainability. Furthermore, it is one of its kind in its study of exclusively the BRICS nations. (Noy & Nualsri, 2011) explored fiscal policy post a natural disaster shock and found that in developing nations fiscal policy is procyclical whereas in developed nations it is countercyclical. In future works, building beyond the BRICS analysis, it would be interesting to include a developing-developed economies analysis.

## **4. Data and Methodology**

### **4.1. Data**

The main source of data this paper leverages on is the World Economic Outlook (WEO) Database of April 2023, which composes of a large selection of annual macroeconomic variables (GDP, Inflation, Fiscal Variables, among others) for most countries of the world, from 1980 until the

most recent estimates for each country<sup>23</sup>. This database is part of a bi-annual WEO survey (published in April and September/October) published by the International Monetary Fund, where it presents IMF's staff economists' analyses of global economic development during the near and medium-term.

As mentioned previously, this paper attempt to include an exploratory effect of natural disasters and climate events on public debt sustainability. For that purpose, we utilize the Emergency Events Database (EM-DAT), created in partnership between the World Health Organization and he Belgian Government in 1988. EM-DAT presents core data on the occurrence and effects of over 22,000 mass disasters in the world from 1900 to the present date. In addition, this paper also endeavors to consider the effect of political stability on public finances, for which we obtain data from the World Bank. This paper gather the World Development Indicators (WDI), which are a compilation of relevant, high-quality, and internationally comparable statistics about global development and the fight against poverty, as well as data from the Worldwide Governance Indicators (WGI) project, which reports aggregate and individual governance indicators for over 200 countries and territories over the period 1996–2021, for six dimensions of governance. This paper has also used a multitude of online resources, including the official central website of the BRICS nations to generate the Election Year Variable.

The paper combine the databases to have an aggregate database of macroeconomic, natural disaster-linked, and political variables, and then subset to BRICS nations in line with our paper's objective. The result is a balanced panel data structure with 5 countries and 20 years of observations.

#### 4.2. Model and Methodology

As part of the already existing literature on debt sustainability analysis and its frameworks, the model starts based on the work from (Bohn, 1998), where the author intends to search for a systematical relationship between the debt-income ratio and the primary balance. This framework

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<sup>2</sup> The IMF includes 5-year ahead forecasts for most countries and macroeconomic variables, but we do not consider them given the scope of the analysis.

<sup>3</sup> The WEO Database does also include estimations of the output gap for several countries. However, for most years and most countries there is no estimation of the output gap. We calculate an output gap for the relevant countries applying an HP filter to GDP at constant prices, in national currency.

is part of the literature which estimates fiscal reaction functions, and empirically (Bohn, 1998) estimates a regression of the form:

$$pb_t = \theta d_t + \alpha Z_t + \epsilon_t$$

Where  $pb_t$  is the ratio of primary balance to GDP in period  $t$ ,  $d_t$  is the (start-of-period) public debt to GDP ratio,  $Z_t$  is a set of other determinants of primary surplus, and  $\epsilon_t$  is an error term. As mentioned by (Bohn, 1998), this framework raises questions about the time series properties of the primary balance and public debt; if  $pb_t$  and  $d_t$  do not have unit roots, a simple regression of  $pb_t$  on  $d_t$  only will produce inconsistent estimates due to omitted variable bias. Importantly,  $\theta$  is the coefficient of interest, as it measures the responsiveness of the primary balance to the debt ratio. It should also be noted that “*While Bohn shows that a sufficient condition for the government to satisfy its intertemporal budget constraint is that the primary balance always reacts positively to lagged debt, this can be thought of as a weak sustainability criterion that does not, for example, rule out an ever-increasing debt-to-GDP ratio (and thus the need for a primary surplus that eventually exceeds GDP)*” (Ghosh, Kim, Mendoza, Ostry, & Qureshi, 2013).

This paper’s empirical model for this paper is an extension of the previous relationship. Following the work of (Ogbeifun & Shobande, 2020) we have

$$pb_{i,t} = \alpha + \delta pb_{i,t-1} + [\theta d_{i,t-1}] + [\beta X_{i,t}] + [\omega Z_{i,t}] + \gamma_i + \lambda_t + \epsilon_{i,t}$$

As mentioned before,  $pb_{i,t}$  is the primary balance to GDP ratio for country  $i$  at time  $t$ ,  $d_{i,t-1}$  is the 1-year lagged debt-to-GDP ratio,  $X_{i,t}$  is a vector key macro<sup>4</sup> determinants of the primary balance,  $Z_{i,t}$  is a vector of natural disaster and political stability variables,  $\gamma_i$  are country fixed effects,  $\lambda_t$  are time dummies, and  $\epsilon_{i,t}$  is the error term. Like (Ogbeifun & Shobande, 2020), this paper’s choice for the macro determinants of the primary balance follows the work from (Abiad & Baig, 2005). The base specification for the fiscal reaction function includes the lagged primary balance to GDP ratio and lagged public debt-to-GDP ratio. As for the other determinants of the primary balance, we include: (i) interest payments on public debt, (ii) the current account balance, (iii) the

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<sup>4</sup> Similar to the work from (Ogbeifun & Shobande, 2020), we include the election year here as macro-political variable which influences primary balance.

output gap (as our business cycle indicator variable), (iv) headline inflation, and (v) the election year dummy.

This paper contributes to previous work in two empirical aspects: (i) realizing the analysis for BRICS nations, and (ii) we include natural disaster and political stability variables. The natural disaster (damages) variable we use is the total estimated damages in the year of occurrence (unadjusted for inflation) in USD, and we divide such amount by nominal USD GDP for each country and time period<sup>5</sup>. For political stability, we use the following Worldwide Governance Indicators: (i) Control of Corruption, (ii) Regulatory Quality, (iii) Political Stability and Absence of Terrorism, and (iv) Government Effectiveness.

Given Bohn's annotation regarding the time series properties of the variables, this paper applies second-generation panel data unit root tests to evaluate the order of integration of the variables in the model, since these tests tolerate cross-sectional dependence (Pesaran, 2007). Importantly, we acknowledge the dynamic panel data structure of the empirical model being utilized. However, given the structure of our panel data, our time dimension is reasonably larger than our cross-sectional dimension, by which we argue that any potential bias on the auto-regressive parameter would be negligible (Bond, 2002), especially in cases where the time series properties our variables show very low persistence. Lastly, this paper runs a Feasible GLS to account for any heteroscedasticity and cross-sectional dependence problems.

Table 1 is presented below detailing the regressors in all our models:

<i><b>Model</b></i>	<i><b>Independent Variables</b></i>
1	Lagged Debt to GDP Ratio; Lagged Primary Balance
2	Model 1; CAB; Interest Payments; Output Gap; Election Year Dummy; Inflation
3	Model 2; Natural Disaster Variable
4	Model 3; Political Variables

***Table 1***

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<sup>5</sup> For cases in which there were 2 or more natural disaster or climate events in the same country in the same year, we add the estimated costs to account for a single observation.



## 5. Empirical Results and Discussion

### Descriptive Statistics

Statistic	N	Mean	St. Dev.	Min	Max
Primary.balance_GDP	115	-0.664	3.415	-9.212	8.342
Public.Debt_GDP	115	49.608	24.932	7.446	96.840
CAB_GDP	115	0.737	4.155	-5.326	16.309
Interest_GDP	115	2.962	2.236	-0.308	8.417
Output_Gap	110	-0.282	2.620	-5.960	9.096
Election.Year.Dummy	110	0.209	0.409	0	1
Inflation	115	5.999	3.710	-0.471	20.200
Damages_GDP	115	0.178	0.310	0.000	2.425
Control.of.Corruption.y	100	-0.365	0.381	-1.141	0.484
Government.Effectiveness.y	100	-0.014	0.314	-0.602	0.841
Regulatory.Quality.y	100	-0.114	0.332	-0.583	0.820
Political.Stability.y	100	-0.562	0.422	-1.515	0.328

*Table 2*

Table 2 displays the summary statistics specific to BRICS nations for the ratio of primary balance to GDP, debt-to-GDP ratio, the current account balance as a percentage of GDP, the interest payments as a percentage of GDP, the output gap (as our business cycle indicator variable), the election year dummy, headline inflation, total estimated damages (from natural disasters) as a percentage of GDP, and our political variables - control of corruption, government effectiveness, regulatory quality, and political stability. The mean value for the primary balance as a percentage of GDP is -0.664% (3.4%), whereas for the debt-to-GDP ratio it is 49.6% (24.93%).

### Panel data unit root tests

S.No	Name of Variable	CIPS Stat Level	P-Value	CIPS Stat First Difference	P-Value	Order of Integration
1	Primary.balance_GDP	-3.931	4.23E-05	-	-	I(0)
2	Public.Debt_GDP	0.27507	0.6084	-3.5737	0.000176	I(1)
3	CAB_GDP	-2.1019	0.01778	-	-	I(0)
4	Interest_GDP	-1.9184	0.02753	-	-	I(0)
5	Output_Gap	-4.8642	5.75E-07	-	-	I(0)
6	Election.Year.Dummy	-9.9374	2.20E-16	-	-	I(0)
7	Inflation	-3.7823	7.77E-05	-	-	I(0)
8	Damages_GDP	-8.24	2.20E-16	-	-	I(0)
9	Control.of.Corruption.y	-1.0561	0.1455	-9.2538	2.20E-16	I(1)
10	Government.Effectiveness.y	-1.888	0.02952	-	-	I(0)
11	Regulatory.Quality.y	-1.2292	0.1095	-11.824	2.20E-16	I(1)
12	Political.Stability.y	-1.5355	0.06233	-10.607	2.20E-16	I(1)

*Table 3*

To test for stationarity, the paper employs the Im-Pesaran-Shin Unit-Root Test. The dependent variable and all independent variables apart from debt-to-GDP ratio, Control of Corruption, Regulatory Quality, and Political Stability, were stationary. The first-difference was taken for these four variables and they were found to be stationary.

#### **Cross sectional dependence and heteroscedasticity**

<i>Test For Heteroskedasticity</i>			
<b>Name of Test</b>	<b>Test Statistic</b>	<b>P-Value</b>	<b>Result</b>
Studentized Breusch-Pagan Test	16.93	0.1523	No Heteroskedasticity

<i>Test For Cross-Sectional Dependence</i>			
<b>Name of Test</b>	<b>Test Statistic</b>	<b>P-Value</b>	<b>Result</b>
Pesaran CD Test	3.7764	0.0001591	Cross-Sectional Dependence

***Table 4***

To test the presence of cross-sectional dependence, the ‘Pesaran CD test for cross-sectional dependence in panels’ was used. The resultant p-value was extremely small hence the null hypothesis of no cross-sectional dependence was rejected. Cross-sectional dependence was expected in the sample since each BRICS nation’s decisions influences the others countries’ macroeconomic variables. Russia, China, and India, are not only politically aligned but also share geographic proximity.

#### **Fixed Effects**

	Dependent variable:			
	Primary.balance_GDP			
	(1)	(2)	(3)	(4)
l_Public.Debt_GDP	−0.007 (0.021)	−0.047** (0.021)	−0.049** (0.021)	−0.050** (0.023)
l_Primary.balance_GDP	0.564*** (0.086)	0.349*** (0.082)	0.346*** (0.082)	0.207** (0.085)
CAB_GDP		0.365*** (0.099)	0.383*** (0.104)	0.353*** (0.103)
Interest_GDP		1.034*** (0.281)	1.032*** (0.282)	1.022*** (0.272)
Output_Gap		0.435*** (0.084)	0.432*** (0.085)	0.494*** (0.080)
Election.Year.Dummy		0.006 (0.495)	0.085 (0.515)	−0.067 (0.483)
Inflation		0.084 (0.077)	0.081 (0.077)	0.033 (0.078)
Damages_GDP			−0.453 (0.790)	−0.174 (0.755)
Control.of.Corruption.y				5.509*** (1.825)
Government.Effectiveness.y				−4.557*** (1.466)
Political.Stability.y				−0.410 (1.132)
Regulatory.Quality.y				2.293 (1.571)
Observations	110	105	105	100
R <sup>2</sup>	0.334	0.556	0.557	0.642
Adjusted R <sup>2</sup>	0.295	0.503	0.500	0.574
F Statistic	25.812*** (df = 2; 103)	16.617*** (df = 7; 93)	14.476*** (df = 8; 92)	12.430*** (df = 12; 83)

Note:

\*p<0.1; \*\*p<0.05; \*\*\*p<0.01

**Table 5**

Table 5 displays the results of the Fixed Effects regressions. Model 1 regresses Primary Balance as a percentage of GDP on lagged debt-to-GDP ratio and the lagged Primary Balance. The coefficient of lagged debt-to-GDP ratio is negative and insignificant. Model 2 adds additional independent variables such as current account balance as a percentage of GDP, the interest payments as a percentage of GDP, the output gap, the election year dummy, and headline inflation. In model 2, the coefficient of lagged debt-to-GDP ratio is negative and statistically significant. Model 3 adds the natural disasters damages variable, and the coefficient of lagged debt-to-GDP ratio witnesses a slight increase in magnitude and remains significant. In model 4 where the political variables are included, the coefficient of lagged debt-to-GDP ratio further increases in magnitude. Model 4, with all the variables included, has the highest explanatory power amongst all models, as it has the highest adjusted R-squared.

### Random Effects (FGLS)

Variable	Dependent Variable			
	Primary.balance_GDP			
	(1)	(2)	(3)	(4)
l_Public.Debt_GDP	-0.003 (0.005)	-0.057*** (0.009)	-0.074*** (0.015)	-0.081** (0.030)
l_Primary.balance_GDP	0.572*** (0.022)	0.415*** (0.032)	0.481*** (0.048)	0.385*** (0.115)
CAB_GDP		0.452*** (0.047)	0.420*** (0.05)	0.215* (0.102)
Interest_GDP		1.124*** (0.064)	1.222*** (0.08)	1.376*** (0.138)
Output_GDP		0.526*** (0.048)	0.450*** (0.066)	0.453*** (0.107)
Election.Year.Dummy		-0.022 (0.031)	0.107 (.) (0.063)	-0.163 (0.282)
Damages_GDP			-0.481** (0.149)	-0.703 (0.710)
Inflation				0.047 (0.064)
Control.of.Corruption.y				5.421* (2.128)
Government.Effectiveness.y				-3871** (1.119)
Political.Stability.y				0.532 (0.906)
Regulatory.Quality.y				3.037* (1.397)
Hausman Test ( <i>in comparison with the respective FE Model</i> )	[0.981]	[9.657e-06]	[0.8166]	[0.456]
Goodness of Fit	0.731631	0.8243541	0.8204141	0.8323744

**Table 6**

Table 6 displays the results of the four specifications using FGLS. Across all four models the coefficient of lagged debt-to-GDP ratio is larger in magnitude (more negative) in the FGLS regressions compared to the FE regressions.

Current account balance as a percentage of GDP, interest payments as a percentage of GDP, and the output gap, have a positive and significant across all four models in both FGLS and FE regressions. The damages from natural disasters have a negative and significant coefficient in Model 3 in the FGLS regressions, implying that an increase in damages decreases the primary balance, which was expected based on the literature. The significance disappears when the political variables are added to the model. Control of corruption has a positive and significant coefficient in both FE and FGLS model, which is in line with the reasoning that an increase in the control of

corruption implies reduction of corruption and in-turn a higher primary balance if corrupt government expenditures are reduced. Government effectiveness has a negative and significant coefficient in both FE and FGLS regressions, which is an interesting outcome and differentiates the outcome of this paper from other research in this avenue. This implies that those with lower primary balances tend to spend more— perhaps because more of their spending is being translated into productive economic activities – relative to governments that are not effective. Furthermore, regulatory quality has a positive and significant coefficient in the FGLS model, as better regulatory quality and good governance aids in the debt accumulated by the government being utilized well.

The negative and significant coefficient of lagged debt-to-GDP ratio indicates that an increase in the central government debt will decrease the primary balance. A positive coefficient would have implied that with increases in debt, a sustainable debt management plan would aim at increasing the primary balance to finance the debt. The presence of a negative coefficient implies that the debt management behavior of the BRICS region is not sustainable. A few countries may bring down the region as a whole, as previous literature suggests that Brazil, Russia, and South Africa have lower debt sustainability levels in comparison with India and China (Joy & Panda, 2020).

The Hausman test revealed that in three out of four model specifications it is better to use the Random Effects (Feasible Generalized Least Squares (FGLS)) model over the Fixed Effects model. The specification with the macroeconomic controls but without the natural disaster damages variable and the political variables, had a p-value less than 0.05 hence rejecting the null hypothesis of both models being consistent. Thus, for this specification according to the Hausman test it is more beneficial to employ the Fixed Effects model.

## **6. Further Research**

Even though the results in this paper contribute to already existing literature regarding public debt sustainability and the fiscal reaction function, we note a potential agenda that could be carried out to further enrich the ongoing research.

First, our selection of BRICS nations stands on the fact that these economies have become of relatively high importance over the past decades, and a proper analysis of their public finances and the sustainability of their public debt is important after the fiscal expansion of the COVID-19 pandemic. Notwithstanding such concerns, with further data gathering one could extend this analysis to different groups of countries, as evidenced by the empirical literature mentioned above.

One empirical application of particular interest for credit rating agencies (which must evaluate the situation of public finances for several countries with market access), is performing an estimation of the fiscal reaction function for countries of different credit rating, and comparing the resulting relevant coefficients. For instance, under our framework, it should be expected that countries with higher credit ratings have higher  $\theta$  estimates than countries with lower credit ratings, under the understanding that our empirical model tests for  $\theta$  values as examinations of ‘weak debt sustainability’ (Ghosh, Kim, Mendoza, Ostry, & Qureshi, 2013).

Another potential source of extension on current research is considering several different specifications of the empirical model to be utilized. For instance, (Joy & Panda, 2020) drop the lagged primary balance term (which eliminates the dynamic panel structure) and instead use country specific dummies and interaction terms with the lagged public debt to carry out their analysis. In addition, (Ghosh, Kim, Mendoza, Ostry, & Qureshi, 2013) also drop the lagged primary balance term, and instead focus on a cubic specification of the lagged public debt on the empirical model; they focus more on the marginal effects and the levels at which lagged public debt starts to have negative effects on primary balance. With no concrete and specific theoretical underpinning of an empirical model to estimate, the above-mentioned specifications and approaches could also be explored in the context of our contributions (i.e., natural disaster and political stability variables).

Lastly, on a more technical note, this paper has not explored the panel cointegration framework as, based on the panel unit root tests carried out, this approach did not seem necessary. Nonetheless, a panel co-integration approach could also yield interesting results, but a properly specified empirical model would require a more concrete existing theoretical framework.

## **7. Concluding Remarks**

This paper has applied an augmented empirical test on public debt sustainability on BRICS nations, which is part of the already existing Fiscal Reaction Function literature, in which the effect of natural disasters and political variables is included. The main finding is that for BRICS nations, primary balance reacts negatively to lagged public debt, which implies evidence that public debt is not sustainable. This result is consistent across different versions of the model applied, and also across different estimation methods. The findings serve as a contrast to the existing literature,

specifically for BRICS nations, in which results find that the sustainability depends on high and low levels of public debt as compared to the sample mean.

The paper also focuses on the inclusion of cost of natural disasters and political stability variables as new and relevant controls which might help explain the movements of the primary balance. On one hand, the cost of natural disaster and climate events is found to not have a significant effect on primary balance movements. On the other hand, several political stability variables are found to have a significant effect. In particular, control of corruption and regulatory quality are found to have a positive effect on primary balance, whereas government effectiveness has a negative effect on primary balance, a new result.

The results have very straightforward potential policy implications. First, very careful and pre-emptive analysis of public finances should be carried out for the BRICS nations. Despite the empirical test carried out, de-facto default risk and particular debt dynamics (such as a persistently increasing public debt-to-GDP ratio) must be closely monitored for these nations, especially in a context of rising interest rates. Second, the interdependence between political and economic realities in terms of public finances must be taken into account. Close control of corruption and regulatory quality, as well as recurrent evaluation of government effectiveness are key variables to inspect when looking at the sustainability of public debt.

The paper acknowledges the need for further research in this topic, given its relevance in today's economic context of rising interest rates.

## 8. Appendix

### A – IMF Sovereign Risk and Debt Sustainability Framework for Market Access Countries

The following is an extract of the IMF Sovereign Risk and Debt Sustainability Framework (SRDSF) regarding debt dynamics and drivers in the SRDSF (International Monetary Fund, 2022). For any specific country, we can express public debt as<sup>6</sup>

$$D_t = \frac{e_t}{e_{t-1}} D_{t-1}^f + D_{t-1}^d + i_t D_{t-1} - PB_t + SFA_t$$

Where  $D_t$  represents total public debt,  $e_t$  is the nominal exchange rate, the subscript  $f$  denotes foreign currency debt and  $d$  denotes domestic currency debt,  $i_t$  is the implicit average interest rate,  $PB_t$  is the primary balance, and  $SFA_t$  are other stock-flow adjustments. Taking into account that debt is typically analyzed when expressed as a percent of GDP and introducing the term for nominal exchange rate changes  $(1 + \epsilon_t)$  we will have.

$$\frac{D_t}{Y_t} = (1 + \epsilon_t) \frac{D_{t-1}^f}{Y_t} + \frac{D_{t-1}^d}{Y_t} + i_t \frac{D_{t-1}}{Y_t} - \frac{PB_t}{Y_t} + \frac{SFA_t}{Y_t}$$

Moreover, the above equation can be rearranged as follows: (i) observing that  $Y_t = Y_{t-1}(1 + g_t)(1 + \pi_t)$ , (ii) using lower-case symbols to denote all ratios to GDP, (iii) introducing the term for nominal GDP growth ( $\rho_t = (1 + g_t)(1 + \pi_t)$ ), and (iv) expanding  $(1 + \epsilon_t)(1 + i_t^f) = (1 + i_t^f) + \epsilon_t(1 + i_t^f)$  we will have

$$d_t = (1 + \epsilon_t) \frac{d_{t-1}^f}{\rho_t} + \frac{d_{t-1}^d}{\rho_t} + i_t \frac{d_{t-1}}{\rho_t} - pb_t + sfa_t$$

Lastly, to analyze changes to public debt subtract last year's public debt stock from both sides of the equation and consider  $\Delta d_t \equiv d_t - d_{t-1}$ . We have:

$$\Delta d_t = (1 + \epsilon_t) \frac{d_{t-1}^f}{\rho_t} + \frac{(i_t - [\rho_t - 1])d_{t-1}}{\rho_t} - pb_t + sfa_t$$

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<sup>6</sup> Under this formulation, countries are assumed to have debt in foreign currencies. In addition, for analytical purposes the interest bill is expressed in terms of 'effective' (i.e., implicit average) interest rates multiplied by the stock of last year's debt.



This equation explains how public debt dynamics (i.e., the change from one year to the next) are explained by changes in the nominal exchange rate, the implied average interest rate, GDP growth rates, inflation, primary balance, and other stock-flow adjustments<sup>7</sup>.

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<sup>7</sup> Further rearrangements can be made this the above equation to include an expression with the real exchange rate.

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