PUBLIC DEBT AND FISCAL POLICY: A STRUCTURAL DECOMPOSITION ANALYSIS

by

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CERTIFICATE

This is to certify that this thesis entitled: **"Public Debt and Fiscal Policy: A Structural Decomposition Analysis"** submitted by **Ms. Nehan Kushi** is accepted in its present form by the School of Economics, Pakistan Institute of Development Economics (PIDE), Islamabad as satisfying the requirements for partial fulfillment of the degree in Master of Philosophy in Economics.

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I, Ms. Nehan Khushi, hereby state that my MPhil thesis titled "Public Debt and Fiscal Policy: A Structural Decomposition Analysis" is my work and has not been submitted previously by me for any degree from Pakistan Institute of Development Economics or anywhere else in the country/world.

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Nehan Khushi

Dedicated

To my beloved Parents and Family

whose unwavering support, countless sacrifices, and infinite love have been my foundation and inspiration. Their steadfast faith and gentle guidance illuminated my path through every challenge. This work stands as a tribute to their enduring strength and belief in me, a reflection of the love that carried me to the finish line.

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ABSTRACT

The public debt to GDP ratio has undergone substantial fluctuations over both the short and long run. The global debt-to-GDP ratio rose to 100% during the 2020 COVID-19 pandemic, retracting substantially by 2022. Thus, this paper analyzes the drivers of public debt dynamics in Pakistan using macroeconomic data from 1980Q1 to 2023Q4 through the Bayesian Structural Vector Auto-regression (SVAR) model, identified via sign and the narrative restrictions. The primary objective is to quantify the contribution of the identified shocks to fluctuations in the debt-to-GDP ratio and to explore their short- to medium-term macroeconomic effects. The impulse responses reveal that demand shocks accounting for (-4.69 PP) lead to short-term economic expansion but ultimately increase the debt ratio due to external imbalances and fiscal pro-cyclicality. The positive supply shock (5.50), in contrast, reduces the debt by fostering output without the proportionate fiscal expansion, aligning with Pakistan's productivity-driven growth episodes. Moreover, the primary balance shocks (7.52) demonstrate immediate debt-reducing effects with minimal adverse impact on GDP, especially when narrative restrictions are incorporated to isolate the exogenous episodes.

Keywords: Public debt, Fiscal consolidation, Structural Vector Auto-regression

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List of Abbreviations

CAPB	Cyclically Adjusted Primary Balance
DPS	Debt Policy Statement
DSA	Debt Sustainability Analysis
FRDL	Federal Responsibility and Debt Limitation
GDP	Gross Domestic Product
IMF	International Monetary Fund
IRF	Impulse Response Function
MOF	Ministry of Finance
NSS	National Savings Scheme
PIBS	Pakistan Investment Bonds
PRGF	Poverty Reduction and Growth Facility
SBP	State Bank of Pakistan
SVAR	Structural Vector Auto-Regression
WDI	World Development Indicators

CHAPTER 1

INTRODUCTION

The Fiscal Responsibility and Debt Limitation (FRDL) Act 2005 defines public debt as the debt owed by the federal and provincial governments and the debt owed to the IMF and consolidated funds. The act implies that any fiscal year's debt-to-GDP ratio should not exceed 60% of the GDP. The high interest rate and increased borrowing costs threaten the financial sector and fiscal stability. The government debt as a share of output has risen in recent decades, making the macroeconomic environment less favorable. The high debt carries a significant risk as it makes the country more vulnerable to external, financial, and economic shocks. Suppose the improvement in the government's primary balance is not made to lower the interest rate and increase potential growth; in that case, the sovereign debt will continue to increase, exacerbating the bank-sovereign nexus. In Pakistan, with limited external funding, the government has relied more heavily on domestic borrowing, resulting in the bank holding of sovereign debt surpassing 60% of its assets (IMF, 2024).

The limited fiscal space also puts pressure on the monetary authority to shift its focus from price stability to supporting financial needs (Ahmed et al., 2021), which increases the financial market volatility, the cost of financing for households and businesses with weak economic fundamentals, as the exchange rate depreciation, capital outflow pressure, and increased expectation of future inflation become more vulnerable (Ali and Khalid, 2019). Adverse shocks, external vulnerabilities, increased short-term debt, and exchange rate overvaluation all increase the probability of financial crises (George, 2023). However, the concessional debt and FDI inflows can help in stabilizing the condition. As Gunay and Can (2022) show that the FDI acts as a channel for economic stabilization

and capital reallocation in a post-crisis environment. Ramzan (2021) also states that the FDI and exchange rate volatility are inversely related in the case of Pakistan.

Moreover, the increased and unsustainable debt level may lead to low private investment (Khan et al., 2025), as investors predict that future taxes will be increased to finance debt repayment, thereby lowering economic growth (Lau, 2022). The unsustainable debt prompts the government to adopt austerity measures, such as increased taxes and spending cuts, to restore fiscal balance. However, this approach creates social unrest and economic contraction, leading to economic stagnation and a challenging cycle of fiscal consolidation (Mohsin et al., 2021).

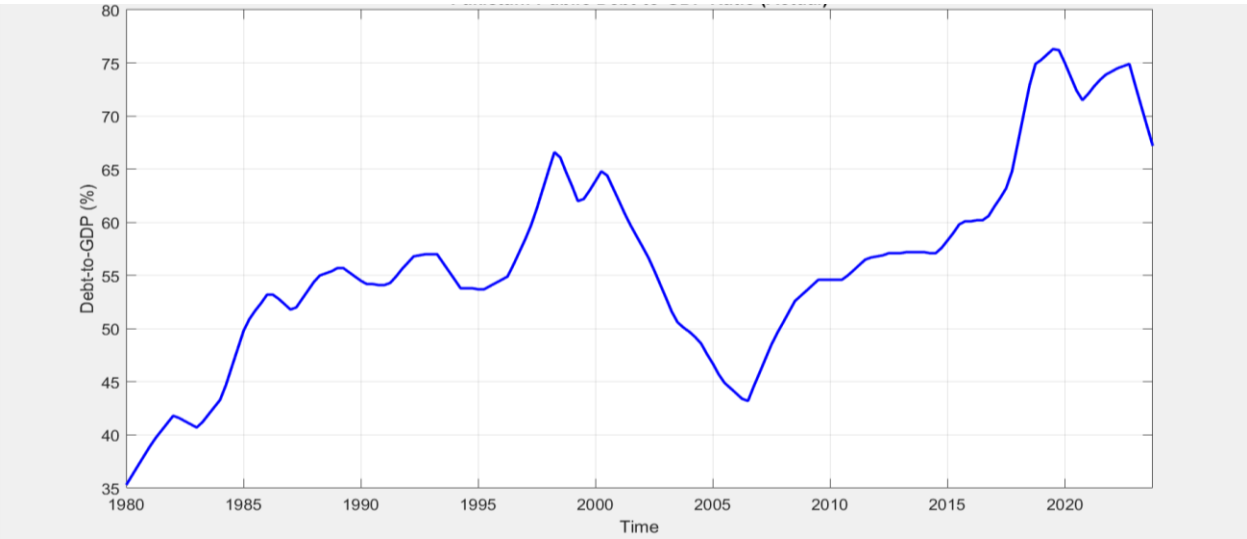

***Figure 1.1*:** Pakistan's Public Debt to GDP Ratio

Figure 1.1 demonstrates the trend in the debt-to-GDP ratio of Pakistan, highlighting multiple challenges, mainly driven by demand, supply, and primary balance side shocks. The reasons[1] vary across different fiscal years. For instance, the financial crisis of 2008 significantly affected

[1] Based on data and analysis in Pakistan Economic Survey 2000 – 2024, particularly focusing on a chapters related to debt management and fiscal development, published annually by ministry of finance, government of Pakistan.

Pakistan's debt-to-GDP ratio due to increased borrowing costs, a higher fiscal deficit, and structural weaknesses. The ratio increased in the year 2009-10 due to a rapid increase in the foreign currency component, as the rupee depreciated by almost 20% against the USD. The absence of external inflows and a large fiscal deficit for several years caused a 13% increase in the public debt during the year 2013. By 2015, the debt had increased, largely due to the dominance of domestic debt. However, fiscal improvement and revaluation gains on the external debt provided a slight relief. By 2018, the situation worsened as public debt surged because of currency depreciation, revaluation losses, and accelerated borrowing for the twin deficits. Recently, the COVID-19 pandemic increased the debt-to-GDP ratio to 80%, as most public spending was used to mitigate the pandemic's effects. So, the borrowing from domestic sources and multinational institutions increases the debt burden. A high level of external debt as a share of total public debt exposes it to exchange rate shocks. These types of structural shocks require higher public support to prevent the economy from collapsing, thereby raising questions about debt management and sustainability.

However, in 2024, the rate of public debt accumulation slowed down due to revaluation gains and fiscal consolidation. The debt-to-GDP ratio decreased to 67.4% in FY24, compared to 74.9% in FY23. The observed slowdown also coincides with the operationalization of the State Bank of Pakistan (SBP) Amendment Act 2021, which redefines the state bank's mandate. The prohibition of direct government borrowing from the SBP and the abolishment of quasi-fiscal credit facilities prioritize price stability over debt financing. This shift curtailed monetized deficit financing and contributed to fiscal discipline, thereby improving debt growth (Jalil, 2021; Javed, 2021).

These fluctuations represent the unsustainable nature of a debt that poses serious economic risks (Fatemah and Haq, 2024). In emerging economies like Pakistan, to design an effective fiscal policy, it is crucial to understand the main drivers of public debt and their transmission via the

macroeconomic variables. The debt-to-GDP ratio is a measure of fiscal sustainability that reflects the interplay of GDP growth, exchange rate, inflation, government revenue, primary balance, and the effective interest rate on debt, each influenced by supply and demand shocks (Mian, 2024). The demand side shocks, like cyclical economic changes or fiscal stimulus, immediately affect debt servicing and revenue collection (Khan, 2024). Moreover, the long-term debt dynamics are shaped by supply-side shocks like external price shifts or structural inefficiencies (Khan and Hanif, 2012). Fiscal consolidation can play an important role in mitigating the effects of demand, supply, and primary balance shocks and hence, improving the economic growth (Qasim et al., 2015). However, its effectiveness depends on the economic condition, timing, and composition. The fiscal consolidation efforts driven by high-level debt or IMF policies have mixed outcomes. In Pakistan's case, this requires a comprehensive understanding of how fiscal consolidation historically responds to economic shocks by examining the interplay of shocks, fiscal consolidations, and economic outcomes (Safdar and Malik, 2020).

The various reports published by the World Bank, the IMF, the SBP, and the Ministry of Finance provide relevant details on debt composition and dynamics. The baseline assumption to predict the future debt and the changes that might occur because of macro-fiscal shocks in the predicted analysis highlights the importance of analyzing the public debt dynamic and quantifying demand, supply, and primary balance shocks, leading to more comprehensive planning and policy recommendations for policymakers. Moreover, the reports provide static assessments and projections; this thesis will quantify the contribution of shocks to the debt dynamics and analyze the fiscal consolidation, whether it is expansionary or contractionary, by evaluating the real economic effect of fiscal consolidation.

Despite the vast literature done on public debt dynamics and fiscal policy e.g Favero (2007), Ilzetzki (2011), Spyrakis (2021), Bischi (2022), Hussain et al., (2022), Sharif and Nawaz, (2024) there exist a marked disparity in quantifying the fundamental shocks and their impact on debt-to-GDP ratios like the supply side shock which may include the exogenous economic shocks, and the demand side shocks like the fiscal adjustments, and also failed to analyze the causal relationship of the fundamental demand, supply and primary balance side shocks with the dynamics of public debt. This quantifying gap hinders the ability of policymakers to design targeted fiscal policies. So, by quantifying the contribution of supply, demand, and primary balance shock on public debt, this study improves the understanding of the interaction between fiscal policy and public debt, thus contributing to better fiscal management in Pakistan. Moreover, a substantial body of empirical literature has focused on fiscal measures on macroeconomic outcomes, and to understand this impact, the studies introduced advanced methods to address the identification and endogeneity issues. This thesis, however, will be the first one to use these methods to focus on Pakistan's debt-to-GDP ratio.

So, this thesis aims to identify the key drivers of fluctuations in the public debt-to-GDP ratio in Pakistan. This thesis uses both Structural VAR and information in narrative data following the previous work done by Merten and Ravn (2013). Following the methodology of Mountford and Uhlig (2009), the core SVAR is based on the sign restrictions for fiscal shocks and growth. Furthermore, following the approach of Diaz and Ramirez (2018), a narrative restriction is used for the primary balance. These narrative shocks are derived from various research, like the work done by Gunter et al (2021), Carriere Swallow et al (2021), and Gujarado et al (2014), which identified the primary balance shift unrelated to the business cycle. Further, the study provides a

novel perspective on the fiscal consolidation impact on GDP by identifying the episodes of exogenous shifts in the primary balance through narrative restrictions.

Unlike the traditional approaches like the debt sustainability analysis framework or the identity equation, this study prioritizes identification through the Bayesian SVAR with the sign and narrative restriction. It is because the DSA framework is mostly used by the IMF or World Bank to assess a country's ability to meet its debt obligations without policy adjustments using a stress test or baseline macro-assumptions (IMF, 2025). So, it predicts the future debt level based on assumptions (World Bank, 2025) but does not explain why the debt changes over time, and our study aims to identify the debt dynamics, not just forecast it. The DSA relies on fixed scenarios (Guzman and Heymen, 2015) that do not capture how the various shocks affect the debt in real time. On the other hand, SVAR shows how the debt reacts to unexpected economic shocks (Gottschalk, 2001), allowing for a causal relationship. In DSA, the variables like interest rate and GDP growth are treated as external variables rather than interconnected; however, the SVAR captures the feedback loop, emphasizing how the fiscal policy influences the variables like interest rate and GDP growth. DSA is mostly used for policy purposes (IMF, 2025) not for the empirical study of decomposing debt accumulation.

Moreover, the study also avoids the standard debt identity equation because the relationship between macroeconomic outcomes and debt-to-GDP is not straightforward (Zubair et al., 2023). The standard debt equation just links the changes in debt to interest rate, primary balance, and GDP growth. The identity equation does not balance in the real-world data, as the large residuals frequently arise because of below-the-line operations, exchange rate changes, and other valuation effects. Moreover, the identity assumes that the debt-to-GDP ratio responds proportionally to GDP growth, but in reality, the debt fluctuates more sharply than GDP, not merely responding to just

GDP fluctuations. Further, it does not capture the causal relationship, fails to separate the shocks, does not explain policy response to debt changes, and endogeneity is not handled.

The empirical model employed in this study uses seven variables: the exchange rate, GDP growth, government revenues, interest rate on debt, primary balance, debt-to-GDP ratio, and inflation. The SVAR identifies three shocks: supply-driven GDP growth shock, demand-driven shock, and a primary balance shock orthogonal to others. The findings show that the fiscal and supply-side shocks are the main drivers of debt movements in Pakistan. The historical decomposition result specifically shows that the supply shock accounts for 72.5% during the debt decrease and 50.4% during the increase, followed by the primary balance shock that accounts for 40.2% during the debt increase and 15.7% during the decrease. The demand shocks contribute marginally, less than 8% overall. Moreover, the impulse response shows that the primary balance shock reduces debt in the short term with minimal GDP contraction, whereas demand shocks exacerbate debt through external imbalances and procyclical fiscal behavior. The results from variance decomposition confirm that the fiscal (32.4%) and supply (35.1%) shocks explain the medium-term variation in debt, with the demand shock (27.7%) playing a relatively modest role. So, the findings suggest that in Pakistan, the debt reduction has historically relied on the occasional fiscal consolidations and supply improvements rather than on macroeconomic demand management. It also shows that there is a need for carefully calibrated fiscal policies that leverage periods of growth for sustainable debt reduction (Fatemah and Haq, 2024).

1.1 Statement of the Problem

A persistent challenge for developing economies like Pakistan is debt sustainability. An increase in the public debt poses a significant threat to the stability of the economy. A cyclical increase has been observed in Pakistan's debt-to-GDP ratio over the last two decades (Ahmad et al., 2024).

Several factors contribute to this persistent increase in debt-to-GDP ratio, like high expenditures, low revenue, extra reliance on imports, and macroeconomic shocks (Sundus et al., 2022). This persistent increase shrinks the fiscal space (Khan, 2025), that is, the ability of the government's public spending, like spending on education, infrastructure, and health, which further deteriorates the economy.

Despite the efforts of fiscal reforms implementation, the fiscal policy of Pakistan fails to address the main reasons for debt accumulation. The existing policies in Pakistan primarily focus on improving revenue generation in the short term and overlook addressing structural inefficiencies. This ignorance perpetuates a cycle of persistent budget deficits and heavy reliance on domestic and external borrowing, even when the borrowing costs are high (Hussain et al., 2022). Moreover, debt servicing already consumes more than half of the federal budget, leaving very little space for public spending and development and making the economy more vulnerable to external and internal shocks (Shabeer et al., 2024).

It is crucial to address these problems because unsustainable debt not only hampers economic growth but also erodes the confidence of the public in financial institutions (Kongo, 2023; Dao, 2017). The incomplete or unclear knowledge of debt dynamics and their relation to fiscal policy creates difficulty in making effective policies of debt management. By focusing on the decomposition of debt, the quantification of shocks, and analyzing the impact of fiscal consolidation on GDP, this research aims to provide insight to policymakers based on evidence to make informed decisions. This problem is important and researchable as it targets the nexus between fiscal policy and debt, which is a forefront economic challenge in Pakistan. The findings will contribute to the academic research and will also offer practical solutions to these issues, which makes the research both policy-relevant and impactful.

1.2 Research Questions

1. What is the composition of the demand side, supply side, and primary balance shock in the debt-to-GDP ratio of Pakistan?
2. What is the impact of fiscal consolidation on Pakistan's economic growth?

1.3 Research Objectives

1. To quantify different shocks (demand, supply, and primary balance) that affect the public debt in Pakistan by focusing on structural decomposition.
2. To analyze the impact of fiscal consolidation on Pakistan's GDP.

1.4 Policy Context

This study identifies and quantifies the share of various shocks (supply side, demand side, and primary balance) and their effect on the debt-to-GDP ratio. It will help to assess the responsiveness of fiscal policy to demand or supply-side shocks. This will provide a framework for policymakers to specify their focus according to the percentage of impact and to decide, based on the fiscal consolidation's impact on GDP, which policy measure should be given more weight to lessen the debt burden. Secondly, this paper identifies the key drivers of public debt, which help policymakers address the specific problematic variable and ensure long-term sustainability.

The remainder of this thesis is as follow. Chapter 2 presents a literature review related to this study, highlighting the empirical findings and theoretical foundations. Chapter 3 focuses on the methodological framework, data, variables, and econometric techniques employed. Chapter 4 presents the estimation and results, offering a thorough analysis and the interpretation of findings. Lastly, Chapter 5 concludes the thesis by summarizing the key insights and providing policy recommendations based on the empirical evidence.

CHAPTER 2

LITERATURE REVIEW

2.1 Empirical Literature

The literature review is linked to the four strands of literature. First, to analyze the key drivers of public debt. Second, to analyze the identification and quantification of the shocks using the SVAR approach. Third, to examine the debt and its relation to economic growth. And lastly, to focus on studies based on fiscal multipliers and the effect of fiscal consolidations.

2.1.1 Key Drivers of Public Debt

Public debt is a critical component of fiscal policy. It reflects the borrowings of the government to support economic growth, finance the budget, and address socioeconomic factors. An extensive part of the literature focuses on analyzing the main driving factors of public debt. This section of the literature review explores the primary drivers that are identified in policy-oriented and academic research. Sundus et al (2022) used a model developed by Mupunga and Raux to determine the drivers of public debt dynamics and applied ARDL bound testing to examine the short and long-term relation between variables and stated that the main drivers of public debt in Pakistan are fiscal deficit, exchange rate depreciation, and interest rate, which are not sustainable. Institutional qualities like regulatory authority, rule of law, governance, and corruption can also affect public debt (Nguyen and Luong, 2021).

Cochrane (2019) used a VAR model for decomposition by using annual data on inflation, surpluses, returns on government bonds, debt-to-GDP ratio, consumption growth rate, and trajectory bill rate. The study found that around 55% variation in debt to GDP is because of changes in future primary surplus expectations, and about 52% variation is because of discount rate

variations. Economic growth is often considered to lower the debt, but from this calculation, it is concluded that the GDP growth accounts for -7% variations in debt-to-GDP fluctuations and is not significant. Further, the study filtered the data to analyze the trends and cyclical variations to understand fluctuations in both short-term and long-term debt-to-GDP ratios. In filtered data, fluctuations in the debt-to-GDP ratio because of the expected future surplus are around 85%, and growth rate and discount rate account for 9% and 7% respectively, different from the unfiltered data results. Moreover, at high frequency, annual changes in the results are different. Around 85% variation is because of changes in expected returns, and 28% is because of future surplus. Das and Ghate (2022) also proximate the drivers of debt from the mechanical decomposition method in India.

Hall and Sargent (2011), while focusing on inflation, the maturity period of debt, nominal interest payment, and real GDP growth, found that inflation, nominal interest rate, and real growth contribute to changes in the debt-to-GDP ratio. So, the literature on the drivers of debt mainly focused on the mechanical decomposition of the proximate drivers of debt-to-GDP ratio fluctuations into components like the primary balance, GDP growth rate, and interest rate based on identities. These estimates do provide information about the proximate drivers of debt, but are silent on the concept of causality and the fundamental primitive shocks behind the fluctuations of debt. Like, let's suppose that the decomposition provides information that the primary balance, to a large extent, causes fluctuations in the debt-to-GDP ratio, but fails to address that the primary balance is also driven by fundamental price shock or the business cycle shock. So, this thesis aims to address these issues.

2.1.2 Identification and Quantification of Various Shocks on Public Debt

To maintain macroeconomic stability and design targeted and effective fiscal policies, it is important to understand the shocks and their role in public debt dynamics. Extensive literature has focused on analyzing, identifying, and quantifying the impact of shocks like the demand-side shocks and supply-side shocks, which are often generated from external or domestic sources.

Mountford and Uhlig (2009) introduced a new method to analyze the effect of fiscal policy shock using a sign restriction for identifying the government expenditure and revenue shock while allowing for the announcement effect possibility and analyzing how the tax cut affects the economy. Does it matter whether the cut is financed by reducing expenditure or by taking a debt? Moreover, they construct an impulse response and impose sign restrictions to identify multiple fundamental shocks like deficit-financed tax cuts, deficit spending, and balanced budget spending expansion. The method applied in the US on quarterly data from 1955-2000 found that deficit financing worked best in improving the economy's GDP. However, the paper has not focused on the effect of the fiscal shocks on the debt. This thesis framework is based on their work, along with a narrative sign restrictions approach by Diaz and Ramirez (2018). Moreover, Patel and Alva (2024) used a structural approach to debt decomposition based on SVAR with sign and narrative restrictions and found that around 40% of fluctuations in debt-to-GDP ratio are because of GDP growth shocks with a co-movement in macroeconomic variables in advanced countries.

The estimates of fiscal policy shock can be inaccurate if the debt dynamic is not incorporated, causing a bias in the result. So, Favero and Giavazzi (2007) used a modified VAR that incorporated the debt variable unlike the traditional VAR model to assess the impact of fiscal policy shocks by taking into account the stock-flow relationship between debt and fiscal variables on debt using quarterly data, concluding that when accounting for debt feedback effect; the government spending

shock largely increases the interest rate and inflation, and tax rate causes more decrease in the interest rate.

Ilzetzki (2016) examined the effect of fiscal policy, taxes, and government expenditure on output. By using the SVAR approach and tax base data of 28 developing countries, the study asserts that the tax cut increases the GDP. If the personal or corporate tax decreases by 1%, the GDP may increase by 0.3-0.4%. The personal tax has more effect than the corporate tax. So, the effect of taxes on output is moderate in developed nations but is significant in developing countries, and a personal income tax rate cut is significant in developing nations. Moreover, tax policies are more effective than government spending in stimulating output, and there is an effect of incorporating debt dynamics in SVAR on estimates of tax cuts and output effects.

Sharif and Nawaz (2024) used the 5-equal SVAR model that incorporates the dynamic debt in fiscal policy shock and checked the responsiveness of output, inflation, and interest rate to the shock. The study concludes that there is a negative correlation between public debt and fiscal imbalance, government spending increases can increase output but also cause short-term inflation, and increased taxes lower the output and have an insignificant impact on inflation.

Abbas and Ameen (2018) used the SVAR model and recursive approach for identification to analyze the fiscal shock impact on macroeconomic variables by using quarterly data. The tax revenue shock increases government spending and negatively influences private investment. Moreover, expansionary fiscal policy increases the public debt service because of fiscal mismanagement.

In Pakistan’s case, to our knowledge, no one has yet quantified the contribution of demand-side shocks, supply-side shocks, or the primary balance shock. It is important to analyze the contribution of shocks for better and more effective policies to tackle the problem of debt-to-GDP

fluctuations. So, by relying on the framework of Mountford and Uhlig (2009) for sign restrictions and Diaz and Ramirez's (2018) approach for narrative restrictions, this thesis aims to identify and quantify the demand-side shock, supply-side shock, and primary balance shock effects on the debt-to-GDP ratio in Pakistan.

2.1.3 Debt and Economic Growth

In the literature, an extensive debate focuses on the debt and its relationship to economic growth. Public debt is used to finance the budgetary balance, development, or to stabilize the economy during a recession or economic downturn. However, the accumulation of debt or the fluctuations in the debt-to-GDP ratio can affect the stability and growth of the economy. This section of the literature review focuses on the empirical evidence on debt and its implications for economic growth.

Spyrakis and Kotsios (2021) state that the fiscal policy was abundant before 2008, but due to the financial crisis, it regained its importance. The debt-to-GDP ratio increased, and the question was raised whether the indebted countries adopt front-loaded, back-loaded, expansionary, or contractionary policies to be safe from defaulting. By using a discrete-time multiplier accelerator model, the study proposed a new fiscal method with flexible fiscal policies and concluded that fiscal policy plays an important role in stabilizing debt and national income, austerity measures depend on economic conditions, and private investments can facilitate faster and less painful recovery and consolidation. The concept of a second relationship highlights the negative impact of sovereign debt on private investments. Taxes and government revenue, together, can stabilize the economy. There is a trade-off between the magnitude of tax rates and the speed of fiscal consolidation. Moreover, the high income level can lessen the debt burden, but if debt increases to a certain level, it can hinder economic growth.

Using the SVAR approach, Simovic (2018) states that a high level of public debt can reduce the effectiveness of fiscal policy. So there is a need for fiscal adjustments. Spending and expenditure changes affect the future budget because of incurred debt. Sundus et al (2022) assert that the instability in the Public debt of Pakistan is major because of the fiscal deficit, the rapid depletion of foreign exchange reserves, currency depreciation, and external account problems.

2.1.4 Fiscal Multiplier and Public Debt

Finally, the last part of the literature review uncovers the macroeconomic impact of the fiscal adjustments, especially on GDP. Countries facing fiscal problems face various questions, like how large the fiscal adjustments should be, and what type of fiscal adjustments should be made, whether it be from the expenditure side or the revenue side. Will the deficit reappear, or will there be a recession because of fiscal adjustments? All these questions are interlinked.

Alesina and Perotti (1997) identified two types of fiscal adjustment. In type one, the study considered cutting taxes by focusing on welfare programs and government wages, and a small tax increase with no increase or further reduction in the tax on households. In type two, the expenditure cut is from the public investment and the broad-based tax increases in households. They found that even if the primary deficit reduction because of the two types of adjustment is the same, the type 1 adjustment is beneficial for fiscal consolidation and is expansionary. While a type 2, it further deteriorates the budget and is contractionary. The reason for type 1 as a better and permanent fiscal adjustment is that the variables (wages and welfare programs) that are tackled in this type tend to automatically increase in the economy. Alesina and Ardagna (1998, 2010) also reached the same conclusion that the spending cut to reduce the deficit is linked to expansion, not a recession in the economy. In short, the fiscal consolidation is linked to economic growth.

Gujarado et al (2014) challenge the expansionary fiscal austerity. He states that to measure fiscal consolidation, the use of the cyclically adjusted primary balance(CAPB) may provide biased results. It may lead to the overestimation of expansionary effects. SVAR is a better approach, but still, it may also not identify the truly exogenous fiscal shocks. The study proposes using the narrative approach for analyzing fiscal consolidation and concludes that, irrespective of the literature supporting expansionary austerity, the effect of fiscal austerity is highly contractionary.

Jorda and Taylor (2015) state that the effect of fiscal consolidation on the economy depends on the state of the economy, whether the economy is in a boom or slump. The study used a propensity score matching to separate the exogenous shock impact and concluded that austerity has a more negative impact during the recession than the boom. There is a 3.5% GDP loss due to 1% fiscal consolidation in a recession compared to 1.8% in a boom.

The most relevant paper to this thesis is that of Mertens and Ravn (2013), as the study developed a strategy for estimation, mixing of narrative information, and SVAR. This thesis's tactics also mix the SVAR and the narrative information to compute the historical decomposition and analyze the different shocks' contribution to the fluctuation of debt to GDP. The fiscal multiplier literature has not discussed the impact on the debt-to-GDP ratio, and as far as the fiscal consolidation impact on the output remains unsettled. So, by using the narrative sign restrictions, this paper will give a novel perspective on both problems. In conclusion, most literature has focused on the fiscal variables only, like taxes and spending, and their impact on GDP (Barnichon et al, 2022). However, this research's crux is to determine the primary balance's direct impact on debt-to-GDP.

2.1.5 SVAR and Narrative Sign Restrictions

In recent research, the narrative approach has been significantly used to study the debt dynamics and fiscal Policy. A significant number of studies analyzed the decomposition of debt into demand

and supply shocks with the use of quantitative tools like the SVAR approach. Yet, the narrative approach provides a qualitative insight into whether they were reactive to the economic shocks or proactively designed to mitigate the potential risks. This approach combines both real-world policy-making and econometric approaches.

Mountford and Uhlig (2009) show that using the sign restriction with narrative data enhances the identification of fiscal shocks. Romer and Romer (2010) used historical records to identify exogenous tax changes in the economy of the U.S. and found that tax changes, unrelated to the economic situation, had a significant effect on macroeconomic variables. To study the fiscal adjustment, Alesina et al. (2015) used historical narratives as they enhance the fiscal multiplier precision and found that spending-based fiscal adjustments are more contractionary than tax-based adjustments. Ilzetzki et al. (2013) examined the pro-cyclical nature of fiscal policies using a narrative approach. Moreover, to examine the austerity measures in advanced economies, Gujarado et al. (2014) also used the narrative sign restrictions.

With the use of sign restriction and narrative technique, this study fills the gap by finding the discretionary fiscal actions and how they interact with supply, demand, and primary balance shock by interpreting the fiscal policies and economic condition of Pakistan using data from 1980Q1 to 2023Q4. The use of narrative restriction with an SVAR approach enhances the methodological rigor of the study and provides insight for policymakers.

2.1.6 Empirical Evidence from Pakistan and Research Gap

The empirical studies on Pakistan's public debt have highlighted the exchange rate depreciation, fiscal deficit, and interest rate as the key drivers of debt accumulation, often leading to unsustainable debt (Sundus et al., 2022). Other studies have examined the dynamic effects of fiscal policy shocks on the macroeconomic variables using the SVAR frameworks, incorporating the

debt feedback to assess the responsiveness of interest payments, output, and inflation (Sharif and Nawaz, 2024; Abbas and Ameen, 2018). Moreover, Hussain et al. (2022) explored the relative effectiveness of spending versus the tax side adjustments in reducing the public debt.

While these studies offer a valuable insight into the determinants of debt and fiscal policy transmission, they often treat debt as a passive outcome rather than decomposing its behavior across the different macroeconomic shocks. Such approaches typically fail to disentangle the relative contributions of different shocks, leaving unclear the drivers of debt dynamics. This study addresses these methodological gaps by employing Bayesian SVAR with narrative sign restrictions, thus allowing for structural identification and orthogonalization of shocks. By decomposing Pakistan's debt-to-GDP ratio into the contributions of supply, demand, and primary balance shock, the analysis not only quantifies the proximate drivers of debt but also isolates the underlying causal mechanisms, offering a more robust understanding of fiscal dynamics and their policy relevance.

2.2 Theoretical framework

To explore the fiscal policy and dynamics of public debt, the theoretical framework links to various theories like the Keynesian fiscal theory, Ricardian equivalence theory, debt overhang, and debt accumulation theory. By synthesizing these theories, this theoretical framework enhances the understanding of underlying principles, provides a solid base for hypothesis formation, and helps policymakers in real-world problem-solving based on evidence.

Keynesian fiscal theory (1936) advocates for the adoption of fiscal policy, and changes in government spending and taxation to stabilize the economy and promote growth, especially during the time of economic downturn. Aggregate demand is the key driver of economic growth. Keynes promotes the idea of active government involvement in adjusting aggregate demand to keep the

economy at full employment. Keynes advocates for countercyclical fiscal policy. Moreover, the Ricardian Equivalence Hypothesis (1970) states that government borrowing does not fully alter the demand decision in the economy because of individual foresight of the future taxes that will be increased to pay the debt. So, individuals adjust their savings according to the borrowing of the government, thus neutralizing the impact of debt on the economy. Bischi et al (2022) discuss the intertemporal budget constraint, which emphasizes that for the sustainability of debt, it is important to meet the intertemporal budget constraint, that is, the current and future revenue should be equal to the current and future debt. In Pakistan, it is central to understand how the limited fiscal space constrains the government's ability to manage debt. The government has to maintain its level of debt and intertemporal budget constraints without defaulting or restructuring.

Krugman and Sachs's (1980) debt overhang theory states that when a country's debt becomes so large, it lowers investment and economic growth. It can also lead the country to a debt trap. Hwang (2010) states that when the debt increases to a certain level, it lowers the chances of the country repaying it, the investor loses confidence, and they expect a lower return because of an increase in taxes. Debt overhang has the potential to hinder productivity development in addition to affecting investment volume.

Lastly, to determine the indicators affecting debt to GDP, this study will rely on the debt accumulation theory by Barro (1980), which links changes in public debt to interest rate, primary balance, and GDP growth rate. The government accumulates debt to finance the budget deficit and to fund investments. In debt accumulation theory, the government faces the intertemporal budget constraint, which is to balance spending and revenue over the long run. Debt accumulation can be sustainable if the economic growth rate is higher than the interest rate (G>IR), but if debt grows faster than GDP, it may lead to a debt trap, debt overhang, or crowd-out effect.

Mele (2021) analyzed debt accumulation, using a model where the government faces a choice between increasing debt and avoiding default. Mele highlights the threshold level after which the debt becomes costlier, and the country is more likely to default. Moreover, to measure the impact of fiscal policy changes like changes in government expenditure and taxes, this study will utilize a fiscal multiplier theory. To understand the relationship between fiscal policy, debt, and economic growth, the methodology incorporates the structural VAR theory, which examines the effects of different shocks on macroeconomic variables.

2.3 Macroeconomic Shocks: Theoretical Implications for Debt

2.3.1 Inflation

The increased inflation can increase the nominal GDP, which can lower the debt if the debt remains stable. Sargent and Wallace (1981) state that the real value of nominal debt decreases if inflation is high, which can benefit the highly indebted countries. Tanzi (1977) states that aggregate demand-driven inflation increases the nominal tax collection, thus increasing the government revenue and improving the fiscal balance. However, excessive inflation can increase the borrowing cost of a government, and increase the interest payments and thus the debt level. Supply-side shocks like the oil price shock can increase inflation because the production cost increases. As Barro (1995) states, cost-push inflation, the increase in input prices, decreases the GDP denominator, hinders the growth of the economy, and thus worsens the debt-to-GDP ratio.

2.3.2 GDP Growth

A demand shock, like a spending increase, can increase GDP growth because if the spending increases, it can increase production and employment, hence decreasing the debt-to-GDP ratio. Keynes (1936) states that expansionary fiscal policies, like increased public spending, in the short

run, especially stimulate GDP growth, thus reducing the debt-to-GDP ratio. The increased growth rate leads to a lower debt-to-GDP ratio (Domer, 1944). Supply-side shocks like the increased cost of production or a reduced supply can affect the GDP growth of a country. GDP growth is in the denominator of the debt-to-GDP ratio. So, if the GDP growth decreases, it increases the debt-to-GDP ratio. Solow (1956) analyzed that the growth in the long run is usually based on productivity improvement.

2.3.3 Interest Rate on Debt

When the demand increases, the central bank increases the interest rate to tackle inflation. The increased interest rate increases the borrowing cost of a government, which can worsen the debt burden of a country. Gale and Orszag (2004) state that expansionary fiscal policies can increase the debt servicing cost. Blanchard (2019) states that the relationship between the interest rate and the growth rate (r-g) matters for debt sustainability. When the growth rate is higher than the interest rate, the debt is considered sustainable. But if the interest rate is higher, it can lead to debt accumulation. To tackle the increased inflation because of increased production cost or lesser supply, the borrowing cost of a government increases, ultimately increasing the debt-to-GDP ratio. The external financial conditions or the monetary tightening globally can also increase the interest rate, especially for the developing nations (Reinhart and Rogoff, 2010).

2.3.4 Primary Balance

When the government revenue increases because of increased production and employment in response to the increased demand, the primary balance increases. A better primary balance can help in lowering the debt-to-GDP ratio. Bohn (1998) considers the primary balance as a key determinant of debt accumulation, and a persistent accumulation of debt can lead to a persistent deficit and thus an increase in public debt. Keynes (1936) analyzed that economic expansion can

increase the primary balance as tax revenue increases, and a recession in the economy can worsen the deficit as the revenues decrease. So, a strong and better primary balance reduces and stabilizes the debt-to-GDP ratio. Thus, lowering the borrowing needs. The supply-side shocks also affect the primary balance. If the subsidy-related expenditure of a government increases, it can lower the Primary balance, thus affecting the debt-to-GDP ratio. Tanzi and Zee (2000) further state that structural challenges like external price shocks or the inefficiency in tax collection, lower revenue collection, and thus increase the deficit.

2.3.5 Exchange Rate

Krugman (1988) examined how the local currency of the foreign-denominated debt directly affects the exchange rate fluctuations. The debt burden increases if the currency depreciates. A demand-side shock, let's say the reduced export or the capital outflow, causes the depreciation of the exchange rate and increases the debt servicing cost. Moreover, the fluctuations in exchange rates directly affect the local currency value. The external supply side shocks, like the global oil price increase, can result in currency depreciation, strain the current account, and thus worsen the debt dynamics (Eichengreen and Hausmann, 1999).

2.3.6 Government Revenue

Economic conditions or cyclical variations have an impact on government revenue. A positive demand shock increases revenue collection as the tax increases (Tanzi, 1977). In a recession or economic downturn, lower revenue further deteriorates the debt-to-GDP ratio. Moreover, if the supply shock reduces the GDP growth, it can also decrease the government revenue. The government has to borrow more if the revenue collection is low, increasing the debt-to-GDP ratio. Besley and Persson (2013) state that structural challenges like the informal economy reduce tax efficiency and limit the revenue collection of the government.

CHAPTER 3

METHODOLOGY, DATA, AND VARIABLES

3.1 Research Strategy and Design

For contextual understanding, the quantitative analysis is chosen as a research strategy for this thesis. As the research is focused on analyzing the drivers of debt, quantifying shocks and their impact, and interpreting results in a fiscal policy context using econometric tools, the quantitative method is appropriate. For analyzing large datasets over time to identify causal relationships, patterns, and trends, the quantitative approach ensures the replicability and robustness of the findings. Moreover, a longitudinal research design is used to track the public debt and debt-to-GDP ratio evolution in Pakistan using historical data from 1980Q1 to 2023Q4. To analyze the long-term relation among the variables and the changes over time, a longitudinal design is better and more appropriate.

3.2 Empirical Analysis

The primary tool of analysis that this thesis utilizes is the Structural vector autoregression (SVAR) model, along with a narrative sign restriction. This is an ideal tool to quantify the shocks and their contribution to debt-to-GDP ratio changes. It ensures robustness by incorporating the theoretical and empirical data. In this section, we analyze how the narrative sign restriction can be used to compute the impulse responses and the historical decomposition, which can be foundational for the upcoming sections. The generalized SVAR can be written as,

$$y_t' A_0 = \sum_{l=1}^{p} y_{t-l}' A_l + c + \varepsilon_t', 0 < t < T \qquad (3.1)$$

In equation 3.1, Y_t is an n*1 vector of the endogenous variables, which includes interest rate, inflation, government revenue, effective interest rate on debt, debt to GDP ratio, and primary balance. E_t, n*1 is a vector of structural shocks. In this study, the structural shocks include demand shock, supply shock, and the primary balance shock. A_l is a n*n matrix for the parameters {L=1,2,3…P}. A_o is an n*n invertible matrix of a relationship among variables. C is a vector of constants and is n*1. T represents a sample size, and P denotes a lag length. Et, a vector depends on the prior information and the initial conditions ($Y_o…Y_{1-p}$). It is assumed that it follows a Gaussian distribution with a zero mean and a covariance identity matrix I_n.

We can also write the SVAR model as,

$$y_t' A_0 = x_t' A_+ + \varepsilon_t', 0 < t < T \qquad (3.2)$$

X_t'= [$Y'_{t-1}…Y'_{t-p}$,1] m*1 is a vector of the constant term and the lagged variables.

A_+ = [A_1', A_2'…A_p', c'] m*n is a structural parameter matrix, m=np+1

For the model, we can write the reduced form as,

$$y_t' = x_t' B + u_t', 0 < t < T \qquad (3.3)$$

Here,

$B=A_0^{-1}A_+$ is a matrix of reduced form parameters.

$U_t= E_tA_o^{-1}$ is a reduced form residual.

For the reduced form parameters, the covariance matrix is given as

$\sum = E[U_tU_t'] = [A_oA_o']^{-1}$

So, B and $\sum$ are the reduced parameters, and A_o, and A_+ are the structural parameters. Let $\phi=[A_o, A_+]$ accumulate the structural parameter values.

3.3 Structural Shocks and Historical Decomposition

In this section, we demonstrate the methodology for computing the historical decomposition and define structural shocks to analyze the dynamic impact of shocks. With observed data and structural parameter value $\phi=[A_o, A_+]$, at time t, the structural shock can be written as,

$$\varepsilon_t'(\Theta) = y_t' A_0 - x_t' A_+, for 1 \leq t \leq T \quad (3.4)$$

Here, Y_t is an endogenous variable vector, x is a vector of constant terms and the lagged variables, A_o is a matrix that denotes a relationship among variables, and A_+ is a matrix of structural parameters for constant and lagged variables.

Historical decomposition analyzes the changes in the variables and the structural shocks' contribution to fluctuations, providing insights into their relative importance. In this study, the historical decomposition will analyze the contribution of demand-side shock, supply-side shock, and primary balance shock to changes in the government revenue, real GDP growth, primary balance, debt-to-GDP, inflation, interest rate, and effective interest rate on debt. Let's say, the j^{th} structural shock contribution to i^{th} variable fluctuation during the period of t and t + h can be written as,

$$H_{i,j,t,t+h}(\Theta) = \sum_{l=0}^{h} e_{i,n}' L_l(\Theta) e_{j,n} e_{j,n}' \varepsilon_{t+h-l}(\Theta) \quad (3.5)$$

Where e_i and e_j are the structural vectors for the i_{th} variable and j_{th} structural shock, respectively. $\epsilon t+h-l(\Theta)$ is a structural shock at t+h−l time. L_l captures the dynamics of shock and represents the impulse response function.

3.4 Narrative Sign Restriction for Identification

This section analyzes the role of the traditional and narrative sign restrictions to explore and address the identification problem in SVAR models. In SVAR, the structural parameters are often not identified in a system of equations without imposing additional restrictions. Such restrictions are necessary as they ensure that the observed data can differentiate between the structural shocks. The traditional sign restrictions are based on common assumptions and previous knowledge. On the other hand, narrative sign restrictions are the extension of the traditional method as they incorporate historical events, ensuring more precise identification of shocks. In recent years, the sign restriction has been alternatively used instead of traditional VAR identification as it identifies the shocks with more flexibility, and the use of minimum restrictions on the impulse response function makes it a better and more effective method. Let's consider any continuous function F(Θ) from structural parameters to the r*n matrix, where r is a natural number. We can express the sign restriction as:

$$S_j F(\theta) e_{j,n} > 0 \qquad (3.6)$$

where, $1 \leq j \leq n$, S_j is a full-row rank matrix and is s_j*n, where $sj \geq 0$. S_j value is the imposed restrictions number that is used to detect the j^{th} shock. The SJ matrices and the F(Θ) express the nature of constraints.

3.5 Significance of Research

Analytically, this study provides insights into debt accumulation and its dynamics by decomposing the drivers of debt. It provides a clear picture of how the supply-side variables, like the condition of the labor market, demand-side factors like inflation, interest rate, and primary balance shock, that is a mismatch in government revenue and spending, contribute to the debt dynamics and

accumulation. This research enhances the understanding of fiscal policy fluctuations in an economy like Pakistan, which is a resource-constrained country.

Theoretically, this study contributes to the existing literature by incorporating famous theories in a comprehensive framework, like the Keynesian fiscal theory, debt accumulation theory, and Ricardian equivalence theory, to understand the dynamics of public debt in Pakistan's case. It further extends these theories by applying them to emerging economies like Pakistan, offering insight into how macroeconomic shocks and fiscal constraints interact to shape the sustainability of debt.

Methodologically, this study employs a robust econometric technique that is a structural vector autoregression with a narrative sign restriction to quantify the impact of various shocks like the demand-side shocks, supply-side shocks, and a primary balance shock. This methodological framework is crucial for understanding the fluctuation in debt.

3.5.1 Policy Significance

The findings of this research will be directly helpful to Pakistan's Policymakers. This study provides evidence-based recommendations by decomposing the drivers of debt and quantifying the economic shocks for fiscal policy sustainability. For economic stability, this research highlights the importance of increasing revenue generation, targeted fiscal adjustments, and strategic debt management. It also provides a framework for policymakers to anticipate macroeconomic shocks and evaluate fiscal measures.

In conclusion, the research covers the gap in the literature and provides actionable insight to improve Pakistan's economic resilience and fiscal policymaking.

3.6 Variables

To quantify the shocks and their impact on debt to GDP, we employed seven variables. Below is the detailed definition of all the variables we aim to utilize in this thesis.

Table 3.1: Specification of Econometric Variables and Data Sources

S.NO	VARIABLES	DEFINITION	SOURCE
1.	Exchange Rate	The value of a unit of foreign currency in terms of domestic currency is known as the exchange rate.	SBP
2.	Inflation	In the economy, over time sustained increase in the average price of goods and services is known as Inflation.	SBP
3.	Government Revenue	The total amount of money that is collected from various sources by the government is known as government revenue to finance public needs and development projects.	SBP
4.	GDP growth	A percentage increase in the value of goods and services produced within a country in a specific period is known as GDP growth. It is used to measure a country's overall economic performance.	MOF
5.	Effective Interest on debt	The interest rate per period paid on the amount of borrowed money is known as the interest rate on debt.	SBP
6.	Primary Balance	A difference between the government revenue and expenditures, excluding the interest payments on debt.	SBP
7.	Debt-to-GDP ratio	An economic metric that compares the country's total public debt to its gross domestic product (GDP). It measures the ability of a country to repay its debt using the revenue of the government.	PES

3.7 Data

The study uses Pakistan's time series quarterly data of seven variables from 1980Q1 to 2023Q4. In the absence of high-frequency fiscal data, to conduct the quarterly structural analysis, the study transforms the macroeconomic annual series into the quarterly frequency using the cubic spline

interpolation. This is to ensure a smooth, piecewise cubic polynomial that passes through each annual data point while ensuring continuity in both the first and the second derivatives. This is essential to avoid artificial volatility and discontinuity and preserve the underlying economic trends in the interpolated series. In various applied settings like the macroeconomic disaggregation (Ajao et al., 2012) and chemical Engineering (Kaya, 2010), this technique has been successfully applied. Ajao et al. (2012) present the robustness of the cubic spline interpolation in disaggregating Nigeria's annual trade data into the quarterly series. The cubic spline offers superior smoothness without the excessive oscillation associated with the higher degree polynomials, compared to the linear or the quadratic method. It makes the cubic interpolation suitable for interpolating the fiscal variables like the revenue, GDP growth, and the debt. It ensures that the interpolated data is both economically meaningful and analytically tractable for the subsequent SVAR estimation. Below are descriptive statistics of the variables.

Table 3.2: Descriptive Overview of Key Macroeconomic and Fiscal Variables

Variable	Mean	Standard Error	Minimum	Maximum	Count
Debt-to-GDP	56.22	0.70	35.30	76.30	176
Total Revenue	15.14	0.14	11.50	18.60	176
Real GDP Growth	4.63	0.14	-0.90	8.70	176
Primary Balance	-1.43	0.13	-4.30	1.90	176
GDP Deflator	9.19	0.37	0.80	25.80	176
Interest Rate	13.11	0.23	8.62	19.89	176
Exchange Rate	66.79	4.20	9.91	284.95	176

Table 3.2 presents the key macroeconomic variable descriptive statistics relevant to Pakistan's debt dynamics. The average debt to GDP ratio of Pakistan stands at 56.22% reflecting the moderate

but persistent fiscal pressure, while the total revenue stood at an average of 15.4% of GDP, highlighting the revenue side structural limitations. With notable volatility, the real GDP growth averages at 4.63% and the primary balance remains in deficit at -1.43%. Moreover, the GDP deflator shows a mean of 9.19% while the interest rate is 13.11% average, indicating a high borrowing cost. The exchange rate values show the substantial depreciation over time, with a maximum of Rs 284.95 and a mean of Rs 66.79, pointing to the external vulnerabilities. These statistics provide a foundational overview of the macro fiscal environment and set the stage for the subsequent econometric investigation into Pakistan's fiscal consolidation pathways and debt sustainability.

3.8 Model Specification

Central to the debt decomposition identity, this study framework includes the seven variables. (1) Government revenue to GDP, (2) Effective interest rate on debt, (3) Primary balance to GDP, (4) Change in debt to GDP ratio, (5) Real GDP growth, (6) GDP deflator inflation, and (7) Exchange rate.

The structural shock identification is based on the combination of both narrative restrictions and sign restrictions. It differentiates the three shocks that are the supply shock and demand shock (GDP growth shocks), and the primary balance shock orthogonal to the growth shocks. The narrative sign restriction is to incorporate institutional and historical information to sharpen the identification of the primary balance shock.

3.8.1 Structural Identification via Sign Restriction

Table 3.3 summarizes the variables used in the estimation of the structural vector autoregression model (SVAR) and the sign restrictions imposed to identify the structural shocks. This model

includes the seven quarterly macroeconomic variables for Pakistan from 1980Q1 to 2023Q4, chosen because of their central role in the fiscal transmission mechanism and the debt dynamics. The identification of the three structural shocks, demand shock, supply shock, and primary balance shock, is grounded in the established literature, following the approach of Mountford and Uhlig (2009). The backbone of identification is set to impose restrictions to identify the two GDP growth shocks and a primary balance shock.

Table 3.3: Sign Restriction Matrix for Fiscal Shock Identification

Variable	Demand Shock	Supply Shock	Primary Balance Shock
Debt-to-GDP			–
Revenue	+		
GDP Growth	+	+	
Primary Balance	–		+
Inflation (GDP Deflator)	+	–	
Interest Rate	+		+
Exchange Rate Depreciation	+	–	

The positive sign (+) indicates that the variable is expected to increase in response to a shock, and the negative sign (-) means that the variable is expected to decrease in response to a shock. Meanwhile, the blank cells mean no restrictions are imposed on the variables.

3.8.1.1. Sign Imposed on Demand Shock: GDP growth (+), inflation (+), revenue (+), interest rate (+), exchange rate depreciation (+), primary balance (–).

So, the demand shock moves the output and inflation in the same direction, with government revenue rising in a pro-cyclical manner. The interest rate increases, and the exchange rate

depreciates due to potentially tighter monetary policy and increased economic activity. The primary balance worsens because of delayed consolidation or higher spending. Such patterns are mostly observed during demand-driven booms or stimulus episodes.

3.8.1.2 Signs Imposed on Supply Shock: GDP growth (+), inflation (–), revenue (+), exchange rate (–).

Similarly, Mountford and Uhlig (2005) describe the supply shock as a shock that embeds the same pro-cyclical movement in government revenue, but output and inflation move in opposite directions. A supply shock is often caused by a favorable external price movement or a productivity improvement that leads to increased output and lower inflation. Due to cost-side improvements, the inflation falls, but the revenue increases as GDP improves. The monetary policy remains accommodative, and the exchange rate appreciates.

3.8.1.3 Signs Imposed on Primary Balance: primary balance (+), interest rate (+), debt-to-GDP (–).

Lastly, a primary balance shock or the fiscal shock is one that increases the primary balance to GDP ratio orthogonal to the output fluctuations. It captures the discretionary fiscal consolidation or expansion, such as tax hikes or spending cuts/increases, not directly tied to the business cycle. The negative response of debt-to-GDP reflects a fiscal tightening, while the rise in interest rates may capture credibility effects or reduced inflation expectations. This shock mirrors narrative-based consolidations identified by Guajardo et al. (2014) and adapted for Pakistan using narrative restrictions where available.

Similar to Mountford and Uhlig's (2009) framework, there are some differences in this study from their approach. Firstly, they only identified a single GDP shock. Unlike their approach, this study

evaluates and quantifies the separate and relevant contributions of demand and supply-side shocks on the debt-to-GDP ratio and economic growth in Pakistan. Secondly, this study emphasizes the primary balance as the main driver of public debt to GDP, unlike a broader fiscal instrument focus in Mountford and Uhlig's (2009) paper, to align with the main objective of the study, and to analyze the main reasons for changes in the debt to GDP ratio, instead of analyzing the relative importance of various fiscal instruments.

3.9 Estimation

This thesis analyzes the contribution of three distinct shocks_ namely, demand shock, supply shock, and the primary balance shock, to the changes in the debt-to-GDP ratio. Following the method of Sims and Zha (1998) and Del Negro (2011), the decomposition of the debt-to-GDP ratio contributors is based on the Bayesian method. For the reduced form VAR, the study has used the 2 lags with Minnesota prior[2], which is reliable for a small sample size data, like in our case (quarterly data from 1980Q1 to 2023Q4). This method provides a shrinkage for the macroeconomic variables towards the random walk, which improves the estimation and prevents overfitting. As proposed in Canova (2007) and Giannone et al. (2015), to maximize the marginal data density, the hyperparameters are calibrated. Following Antolin-Diaz and Rubio-Ramirez (2018), which is built on the Rubio-Ramirez et al. (2010), the study used the sign restriction with the narrative information for the structural identification. These studies use the Haar[3] before drawing the orthogonal matrices consistent with the imposed restrictions.

[2] The Minnesota Prior introduced by Litterman (1986), introduces shrinkage by penalizing large cross variables and high order coefficients, assuming variables follows a random walk to improve the forecast stability.

[3] The Haar prior is a non-informative prior, uniformly weights all orthogonal rotations of shocks in SVAR identification, ensuring an unbiased structural decomposition under sign and narrative restriction.

The Haar prior treats all the rotation matrices that are used to implement sign restrictions as equally likely and shows that the response of the structural impulse prior is invariant to the post-multiplication by the orthogonal matrices. A few recent studies, like Baumister and Hamilton (2015, 2018), doubt the appropriateness of the Haar prior because the rotation matrix itself does not enter the likelihood. So the Haar prior can't be overruled by the data. But Inoue and Kilian (2021) state that in the structural vector auto-regression model (SVAR) that is restricted by the sign restrictions, the impact of the Haar prior is negligible. Also, as stated by Arias et al. (2023), over a set of orthogonal matrices, to have the uniform joint prior and the posterior distribution over the set of identified impulse response vectors when identifying multiple shocks, the uniform prior is not only sufficient but is also necessary.

CHAPTER 4

RESULTS AND DISCUSSION

This section interprets and summarizes the results. The historical decompositions are utilized within the SVAR framework to address the first research question related to drivers of public debt dynamics. The decomposition helps disentangle the cumulative effects of the structural shocks over time on debt evolution. For the second question, related to fiscal consolidation unrelated to the business cycle, impulse responses are constructed using the SVAR with sign restrictions. Moreover, narrative restrictions are applied subsequently to identify the specific consolidation episodes, allowing for a more specific and better interpretation of their economic consequences.

4.1 Structural Debt Decomposition

The structural decomposition of debt shows the changes in the debt-to-GDP ratio from 1980Q1 to 2023Q4 due to demand shock, supply shock, primary balance shock, and residuals. The decomposition offers a structural counterpart to the standard debt accounting methods, with the further advantage that the shocks are orthogonal.

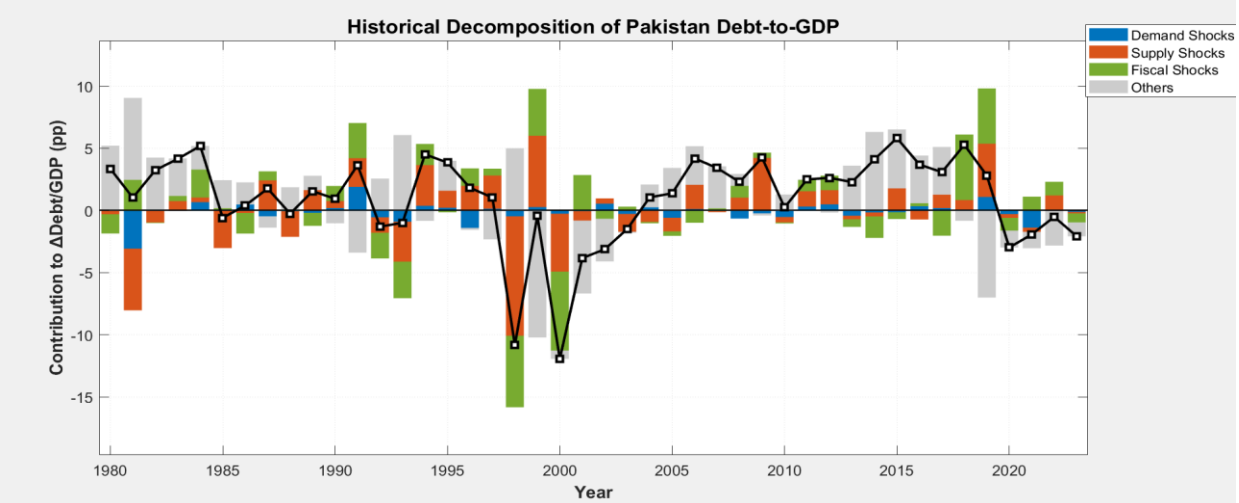

Figure 4.1: Historical Decomposition of Pakistan's Debt-to-GDP

In Figure 4.1, each colored bar represents a different shock contribution to the changes in the debt-to-GDP ratio, with the black solid line tracing the actual observed changes in the debt, allowing for the model-based structural drivers and the realized fiscal outcomes. This decomposition reveals a few important patterns. The blue shaded area shows the contribution of the demand side shock, meaning the business cycle fluctuations, like consumption, fiscal demand, and investment. These shocks generally contribute to the debt reduction (Valencia et al., 2024), specifically during the boom. The orange shaded area shows the contribution of supply-side shocks like productivity shocks, global terms of trade, energy crises, inflationary pressure, oil price, and so on, contributing significantly to the increase in debt (Valencia et al., 2024) in years like 1998, 2008, and 2018. The supply shock role is most prominent during the macroeconomic crises, when the adverse supply conditions increase the fiscal stress through both the higher interest cost and the revenue shortfall, as the oil price shock is found to depreciate the exchange rate, increase interest rate and inflation, and a depressed real GDP (Malik et al., 2017)

Moreover, the green shaded area represents the primary balance shock, a discretionary fiscal shock like revenue policy or spending shifts. It plays a meaningful but asymmetric role. In the period of debt reduction, the primary balance contributes positively, reflecting the deliberate consolidation efforts. However, in the period of debt surges, their contribution is often muted or even negative, suggesting that the fiscal policy has historically been reactive rather than preemptive, aligning with the research by Mansoor et al. (2020), which states a negative relationship between debt and primary balance. Lastly, the grey shaded area represents the contribution of others, which may include the residuals, initial conditions, and shocks that are not identified. These residuals likely reflect the statistical revisions, below-the-line operations, or one-off financing events like the exchange rate revaluations or the IMF disbursements (Joumard et al., 2008). The large contribution

of the other components should not be viewed as a flaw; rather, it serves as a model's specification validation. It shows that the unexplained variations are not driven by the non-economic noise, but are structurally consistent with the model's framework, thereby affirming its credibility and robustness. Its presence confirms that the model focuses on the economic shocks and does not try to fit the non-structural anomalies (Patel and Alva, 2024).

Further, Figure 4.1 shows that there is a moderate debt increase in the early 1980's mostly due to supply shocks and other factors, reflecting the start of external borrowing, rising oil import bills, and weak domestic productivity. In the late 1990's there was an increase in debt due to fiscal shocks and supply shocks because of the 1998 nuclear sanctions, low revenue, and growth and expansion in subsidies. In the early 2000's there was a sharp decline in debt due to fiscal efforts like the IMF poverty reduction and growth facility (PRGF) program, revenue mobilization, and debt rescheduling after 9/11. During 2008 – 2009, there was an increase in the debt-to-GDP ratio due to supply and primary balance shocks like weak reforms, energy circular debt, global financial crisis. Again, there is an increase in debt driven by large fiscal shocks and residuals during 2019 - 2022 due to COVID-19, a drop in tax collection, and emergency spending.

4.2 Identified Shocks Contribution to Public Debt Dynamics

Table 4.1 shows the total contribution of the three identified shocks, namely, the supply shock, the demand shock, and the primary balance shock, to Pakistan's debt-to-GDP ratio changes from 1980Q1 to 2023Q4 based on the Bayesian SVAR along with the standard sign restriction. The contributions are computed across all the years by summing the estimates of historical decomposition. The contribution of shocks is disaggregated into the period when debt increased and the years when debt decreased, allowing for an asymmetric assessment of fiscal dynamics. Several important patterns are revealed from the results.

Table 4.1: Contribution of Identified Shocks to Changes in Debt-to-GDP Ratio

	Overall	Debt to GDP Increase	Debt to GDP Decrease
Demand Shock	-4.69	-3.44	-0.49
Supply Shock	5.50	-3.34	7.59
Primary Balance Shock	7.52	-0.81	8.50
Total Identified Shocks	8.33	-7.59	15.60

The total overall contribution of the identified shocks to the fluctuation in debt to GDP ratio is about 8.33 percentage points, with the largest contribution from the primary balance shock that is 7.52 percentage points, meaning the discretionary fiscal actions like the tax increase or the spending cuts are the major contributor of the fluctuation in debt to GDP ratio in Pakistan (Ministry of finance, 2024; SBP, 2024). There is also a positive 5.50 percentage point supply-side contribution, showing that the adverse structural and cost-side developments, like the inflationary pressure, the energy crises, have worsened the debt-to-GDP ratio in Pakistan (Sikandar and Wahid, 2019). On the other hand, there is a negative 4.69 percentage point contribution from the demand side shock, meaning that the period of strong aggregate demand, often fueled by remittances and consumption, helps to reduce the debt ratio (SBP, 2021), likely due to higher GDP growth.

The asymmetry even becomes more striking when disaggregated by the debt regimes. During the debt-increasing years, the identified shocks' total contribution is (-7.59) percentage points, meaning that the structural shocks contributed to reducing the debt, but were overwhelmed by other factors like the off-budget liabilities, the interest payments, or the exchange rate revaluations (Ministry of Finance, 2024). The supply shock (-3.34) and the demand shock (-3.44) both helped contain debt in these years. While the primary balance shock had a modest stabilizing effect, with the value of -0.81 percentage point. It means that the debt surges in Pakistan are often due to the

non-structural forces or the residuals outside the scope of discretionary fiscal policy, consistent with the findings of Ejaz and Hyder (2019) and the Debt Sustainability Report (2024).

In contrast, during the period of debt decrease, the identified shocks' total contribution is 15.60 percentage points. The most dominant role is played by the primary balance shock (8.50), indicating that during the period of debt decrease, the fiscal policy was less consolidation-oriented than expected. It suggests the pro-cyclical fiscal stance where the government reduces taxes and increases spending even during the time of favorable period, rather than focusing on consolidation. It aligns with Pakistan's fiscal history, including the election years' spending cycle and the populist budget (e.g., 2008, 2013, 2018), as well as the weak implementation of IMF-structured adjustment programs, particularly in the 1990s and 2010s. The overreliance on indirect taxes and the low tax buoyancy also limit the structural fiscal improvements. According to the finance division (2024), Pakistan’s fiscal policy has historically lacked a strong countercyclical anchor, with the primary balance often deteriorating during periods of economic growth.

Similarly, the supply shock contributes (+7.59) during debt-reducing years, suggesting that negative supply shocks, such as inflationary pressure, low productivity, and energy crises, work against the trend of fiscal consolidation. It is consistent with the import fuel price shock, especially during the 2008 global financial crisis and the Russia–Ukraine War in 2022- 23 and the circular debt crisis, which increased to over PKR 2.6 trillion in 2024. So, the Pakistan energy crisis has deepened the fiscal vulnerabilities, with the circular debt and rising tariffs undermining the debt sustainability (Seema et al., 2023; Chohan, 2019).

These results highlight the importance of Pakistan's structural fiscal policy in shaping the debt trajectory. While during the boom, demand-side factors can help reduce debt, it is structural reforms and fiscal discipline that drive sustained and meaningful debt consolidation. The

asymmetry during the debt-decreasing year and the debt-increasing year also highlights the limitations of relying on growth alone or the automatic stabilizers to manage the debt, especially in a context marked by contingent liabilities, fiscal slippages, and external vulnerabilities.

4.3 Asymmetric Contributions of Structural Shocks to Debt-to-GDP Evolution

Figure 4.2 decomposes the median share percentage[4] of three identified structural shocks, namely, the demand shock, supply shock, and the primary balance shock, during the period of debt increase and decrease. Several important asymmetries in the sources of debt dynamics are revealed in the results, with significant implications for macroeconomic analysis and fiscal sustainability.

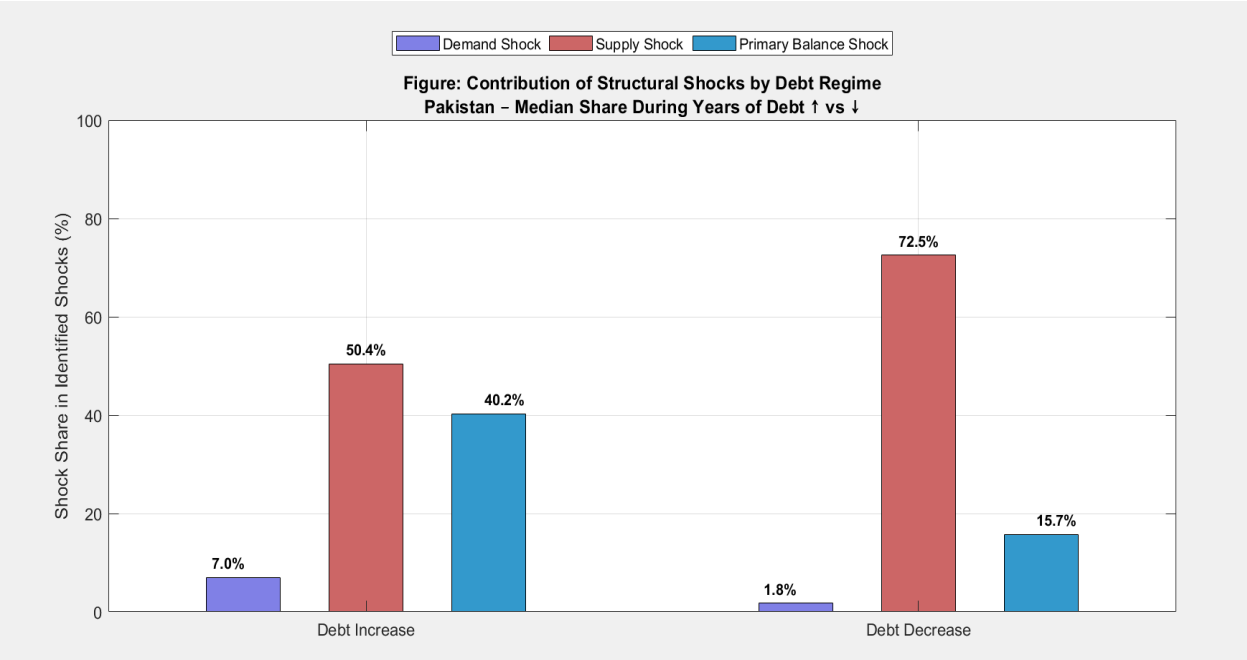

Figure 4.2: Median Share of Identified Shocks during Debt Increase and Decrease

Below is a detailed interpretation of each shock:

[4] For each debt regime, the total median share does not sum to 100% because the chart reports each identified shock median contribution independently across multiple years. Since, the shares are calculated separately for the debt increase and decrease, the medians are taken across time rather than cumulative.

4.3.1 Structural Shock During Debt Increase

The structural shocks identified through the SVAR framework using sign restriction reveal a clear dominance of supply and fiscal side disruptions during the episodes of debt increase. As Figure 4.2 illustrates that the supply shock accounts for 50.4%, the largest share, followed by the primary balance shock at 40.2%, while the demand shock accounts for only 7% playing a minor role. Therefore, it is evident that debt accumulation is primarily driven by unfavorable structural conditions, such as agricultural disruptions, energy bottlenecks, and external trade imbalances, which increase the fiscal cost and constrain output. It is consistent with prior empirical studies from Pakistan, which have highlighted the country's exposure to negative supply-side events, such as the 2022 flood and persistent energy crises, which stall growth and strain public finances (Eng, 2025; SBP, 2023; World Bank, 2022).

Moreover, the response of fiscal policy during the debt increase period appears to be reactive rather than proactive. The primary balance shock reflects the delayed consolidations that surface only when the debt burden rises significantly or due to politically motivated expenditures. This pattern aligns with the findings of Ullah et al. (2024) and Srinivas (2020), who state Pakistan's fiscal stance as pro-cyclical with tightening under duress and expansion during booms, often prompted by IMF conditionality (IMF, 2024). The relatively modest contribution of demand shocks stems from the episodes of brief fiscal overstimulation like credit-fueled consumption booms in FY 2006-08 or FY2021-22, which temporarily widen the trade and fiscal deficit but failed to generate lasting improvement due to limited institutional capacity and weak tax buoyancy (Mian, 2024). Overall, the increase in debt in Pakistan is because of shallow demand cycles, lagged fiscal corrections, and structural vulnerabilities, reinforcing the view that the macro fiscal instability is often a result of crisis-induced adjustments rather than credible long-term planning.

4.3.2 Structural Shocks During Debt Decrease

The period of debt decrease, in contrast, is primarily shaped by favorable supply-side developments accounting for 72.5% of total identified structural shocks, while the contribution of primary balance shock declines to 15.7%, with a demand shock contributing only 1.8% in Pakistan. This distribution reflects the opportunistic nature of debt reduction, which often hinges on external improvements like the energy import relief, export growth, and remittances boom, rather than deliberate fiscal consolidations. Like in FY2024-25, Pakistan witnessed over $40 billion in combined remittances inflows and exports, easing the pressure on the current account and providing fiscal space through improved growth and revenue (SBP, 2024). It highlights the importance of external drivers in improving Pakistan's fiscal indicators, aligning with the literature on macroeconomic stabilization and endogenous growth that emphasizes the role of structural reforms and productivity in sustaining the fiscal health (Mian, 2024).

Moreover, the diminished influence of fiscal policy during the debt reduction points to the limited credibility of fiscal consolidation and weak institutional mechanisms. The Ministry of Finance (2024); Chaudhry and Munir (2010) state that the budget structure of Pakistan suffers from a narrow tax base, rigid expenditures, which limit the effectiveness and scope of discretionary fiscal efforts. Further, the near absence of demand-side shocks during the debt decline underscores the inefficiency of countercyclical policy tools; the monetary transmission remains weak, and automatic stabilizers are largely absent from its fiscal architecture (Shahid et al., 2016). So, the fiscal and monetary improvement during the debt decrease tends to be temporary and externally driven, rather than sustained or policy-induced. Overall, the SVAR results reflect a structural asymmetry; debt is often reduced not through the proactive policy or domestic reforms, but through favorable shocks and external tailwind, revealing a persistent fragility in Pakistan's debt dynamics.

4.4 Benchmarking Empirical Findings with DSA Framework 2025-2027

In benchmarking the results with the Debt Sustainability Analysis (DSA) 2025-27 report of Pakistan, an important contrast emerges. Conditional on improved tax mobilization, strict fiscal consolidation, and stable external inflows, the DSA projects a gradual decline in the debt-to-GDP ratio (Ministry of Finance, 2025). However, this thesis, based on SVAR historical decomposition, suggests that the favorable supply side shocks like remittances, export growth have been more effective than fiscal consolidation in reducing the debt in Pakistan. The primary balance shocks are important during the debt increase, but contribute modestly to the debt reduction, underscoring the limited effectiveness of fiscal policy in anchoring the debt sustainability (Sharif and Nawaz, 2024; Hussain et al., 2022). So, this difference highlights that the DSA framework's credibility depends on addressing the long-standing weaknesses in fiscal institutions and the macroeconomic structure of Pakistan (IMF, 2024; SBP, 2024). Without the parallel structural reforms, Pakistan risks repeating its historical reliance on exogenous shocks to manage debt trajectories rather than the sustained domestic policy discipline. Hence, the future DSAs should explicitly incorporate the asymmetric role of shocks to provide a more realistic assessment of debt sustainability under the economic conditions of Pakistan.

4.5 Dynamic Effects of Structural Shocks

The following figures present the impulse response functions to the positive shocks of the seven key variables derived from the Bayesian SVAR model for Pakistan quarterly data from 1980Q1 to 2023Q4. With the 2 lags, the reduced form VAR is estimated using the Minnesota prior. The sign-restricted Bayesian SVAR approach is used for the structural identification. Using the 100 accepted draws, the median 16^{th} and 84^{th} percentiles of IRFs are shown to construct the 68%

confidence band drawn for the 20 horizons of each macroeconomic variable. The 68% confidence interval is used as standard in the literature, like Sims and Zha (1999), Murphy (2015), etc.

4.5.1 Impulse Response Analysis: Demand Shock

Figure 4.3 shows the macroeconomic variables' impulse responses in Pakistan to a demand shock. The demand shock moves output and inflation in the same direction, with the pro-cyclical movement of government revenue (Mountford and Uhlig, 2005).

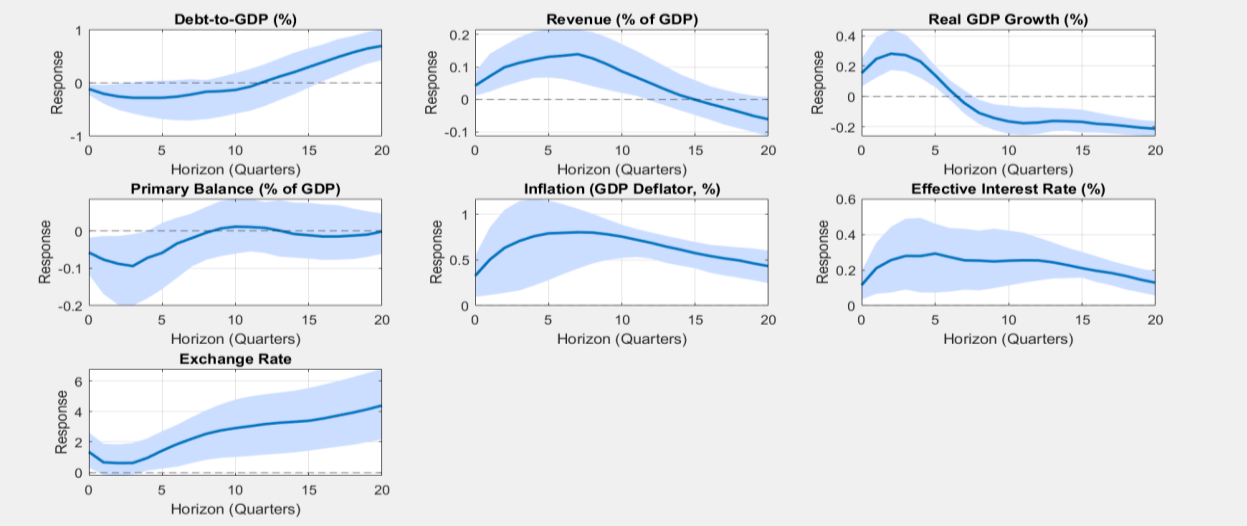

Figure 4.3: Impulse Response to Demand Shock

On impact, the real GDP growth rises sharply and peaks in the short run, showing a typical demand-driven expansion, and then declines negatively. It aligns with Nazir and Hameed (2015), who state that the consumption and price of oil significantly impact real GDP negatively in the long run and positively in the short run. It also aligns with the fiscal multiplier studies in Pakistan, which show that the near-term growth boost comes from the fiscal expansion[5]. The primary balance improves significantly, suggesting a counter-cyclical fiscal response that is front-loaded

[5] Tax policy issues in Pakistan (2000-2020), PIDE

and persistent. The inflation increases steadily, confirming that when the output increases, it induces price pressures, and in response to the higher inflation, the interest rate increases as a tightening stance of the SBP. Moreover, the exchange rate mildly depreciates, a fact that is also observed in the small open economy models (Uribe and Schmitt-Grohe, 2016), possibly due to capital outflow or the import surges in a boom. Overall, the demand shock responses reflect the robust cyclical propagation mechanism in Pakistan.

In conclusion, the response of the interest rate and inflation shows that macroeconomic stability can even erode during the time of a boom, justifying the coordination of fiscal and monetary authorities, as Hakimah (2025) shows that coordination is necessary for economic stability. The exchange rate pattern highlights the increasingly import-dependent economy of Pakistan, creating a vulnerable balance of payments. Lastly, the demand shock must be accompanied by the policy decision, as the fiscal health cannot be improved by a demand shock alone.

4.5.2 Impulse Response Analysis: Supply Shock

Figure 4.4 shows Pakistan's macroeconomic variables' dynamic response to the positive supply shock.

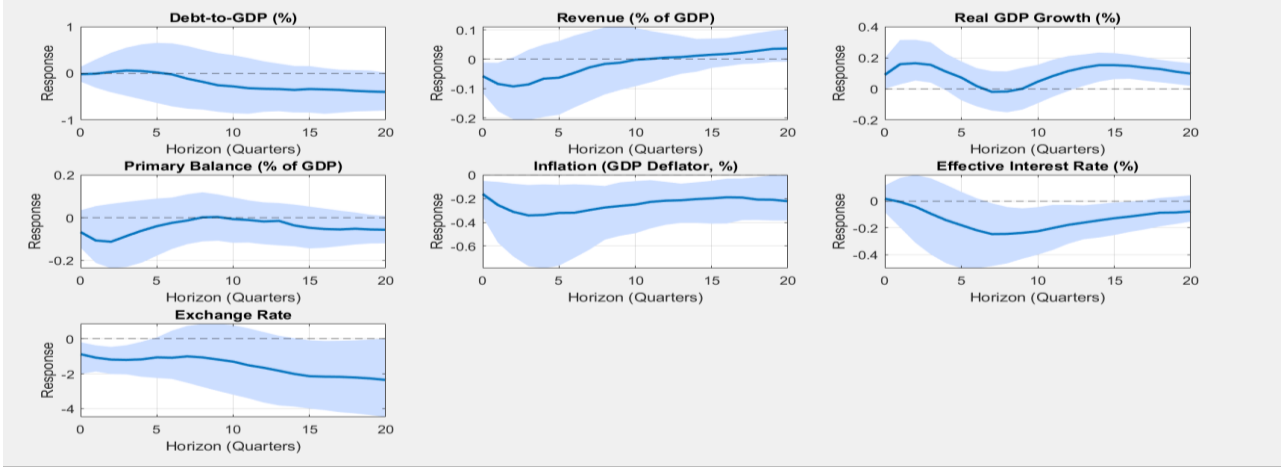

Figure 4.4: Impulse Response to Supply Shock

The supply shock moves output and inflation in the opposite direction, with a pro-cyclical movement of government revenue (Mountford and Uhlig, 2005). Following the shock, the real GDP growth responds strongly in the early quarters, consistent with the theoretical expectations of productivity-driven expansion, but the effect gradually declines, reflecting policy tightening or the diminishing marginal returns, aligning with Pakistan's historical period where the Pakistan growth rate exceeded 7%, before the stabilization pressure emerged (SBP, 2006). The inflation declines following a positive supply shock, reflecting the disinflationary nature of the supply-side improvements as emphasized in the recent empirical VAR studies (Jarocinski and Karadi, 2020), it also aligns with the Pakistan's inflation trend from 2014-2016, when the logistic improvements and the energy supply interventions reduced the cost pressure without stocking demand (Nasir et al., 2017). Similarly, like the demand shock, the primary balance response is front-loaded and mildly expansionary, possibly due to revenue improvement because of higher output (Debortoli et al. 2021), it aligns with early 2000's experience of Pakistan during Shaukat Aziz led reform period (IMF, 2004) where the growth was achieved through the privatization and supply side, while the fiscal deficit remained under control.

The effective interest rate interestingly shows the limited movement, implying a relatively muted monetary policy response, reflecting Pakistan's constrained policy flexibility or preference for output stabilization when facing the favorable cost shocks (SBP, 2020). Consistent with the improved macro conditions and the capital inflows, the exchange rate slightly appreciates, aligning the response pattern with open economy DSGE evidence from the emerging markets (Adolfson et al., 2019). Lastly, the debt-to-GDP ratio declines following a positive supply shock, indicating that the productivity-driven output improvement helps to reduce the fiscal stress over time. These

results are consistent with the findings of the IMF's post-2015 empirical work on debt sustainability and structural reforms in EMDEs (IMF, 2021)

4.5.3 Impulse Response Analysis: Primary Balance Shock

Figure 4.5 shows the impulse response of key macroeconomic variables to the primary balance shock in Pakistan.

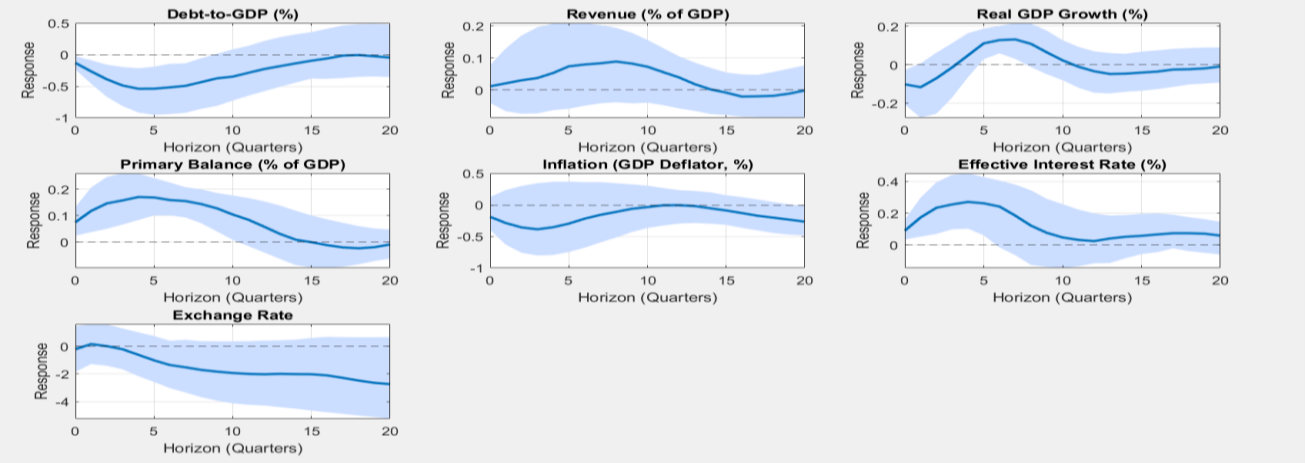

Figure 4.5: Impulse Response to Primary Balance Shock

Figure 4.5 shows that there is a persistent and sharp increase in the primary balance, demonstrating the front-loaded fiscal efforts, but it is followed by a decline after the 5th quarter, aligning with the Pakistan experience of IMF program episodes where the initial improvements are made but is followed by a downfall due to political economy constraints and the external shocks (IMF, 2019).

Real GDP growth also increases modestly till the 4th quarter; it may seem counterintuitive given the conventional Keynesian expectation, but it aligns with the confidence and credibility effect of fiscal consolidation (SBP, 2020; Naseer et al., 2017), where, due to lower sovereign risk, investor confidence improves, supporting the private investment and the short-term growth. Further, the revenue increases positively following a shock over 12-15 quarters, reflecting the revenue-based

adjustments' effectiveness, aligning with the IMF (2022) and FBR's documentation of tax administration reforms.

Moreover, inflation remains below the baseline in response to the shock, supporting the notion that the fiscal consolidation reduces the inflation expectation and demand-side pressures. As noted by SBP (2021), during the 2019-21 consolidation, the core inflation declined, even when the headline inflation remained sticky due to fuel and food components. (Sharif and Nawaz, 2024) also argue that the core inflation dynamics are negatively related to the primary balance improvements. The exchange rate appreciates, suggesting increased investor confidence, reduced financing needs, and improved external balances (IMF, 2021). Lastly, the debt-to-GDP ratio gradually declines, validating the fiscal effectiveness of the shock, even without growth spillovers. This supports the consensus that consolidation can reduce debt even when the growth interest differentials are positive or narrow (Bianchi and Melosi, 2017), but it also reveals the challenge of sustaining gains in the presence of compounding interest and the slower growth aligning with (IMF, 2017).

4.6 The Value of Narrative Information

The preceding analysis relies on the sign restriction alone for the structural identification, a widely used method by Rubio Ramirez et al. (2010). Although these assumptions are standard in the literature but they may leave room for ambiguity in the exact interpretation of the shocks, particularly the fiscal policy shock. The recent macroeconomic empirical analysis has highlighted the importance of incorporating the narrative information in the structural shocks to sharpen the identification (Diaz and Ramirez, 2018; Patel and Alva, 2024). The narrative information enhances credibility by linking the shocks to the historically documented fiscal episodes.

In the case of Pakistan, the narrative restrictions are valuable in isolating the discretionary fiscal consolidations, which might be confounded with the macroeconomic fluctuations otherwise.

While for the demand and supply shock, the credible narrative episodes are unavailable, they do exist for the fiscal actions like the reforms implemented under the IMF-supported programs in 2001, 2008, 2013, and 2019. By using this historical information in the SVAR framework, the narrative restricted approach enables more reliable inference and strengthens the exogeneity of the primary balance shock.

The following section presents the empirical findings for validating the importance of using narrative sign restriction with a focused comparison on the estimated response of primary balance shock with and without narrative sign restriction. This highlights the importance of narrative information, like how the use of even a small number of narrative restrictions helps alter the meaningful interpretation of the fiscal policy effect, aligning with the Giacomini et al. (2022) and Arias et al. (2023).

4.6.1 Narrative Filtering and Structural Precision in Primary Balance Shock

Figure 4.6 displays the posterior distribution during the narrative periods of the primary balance shock, both with and without the narrative restriction imposition.

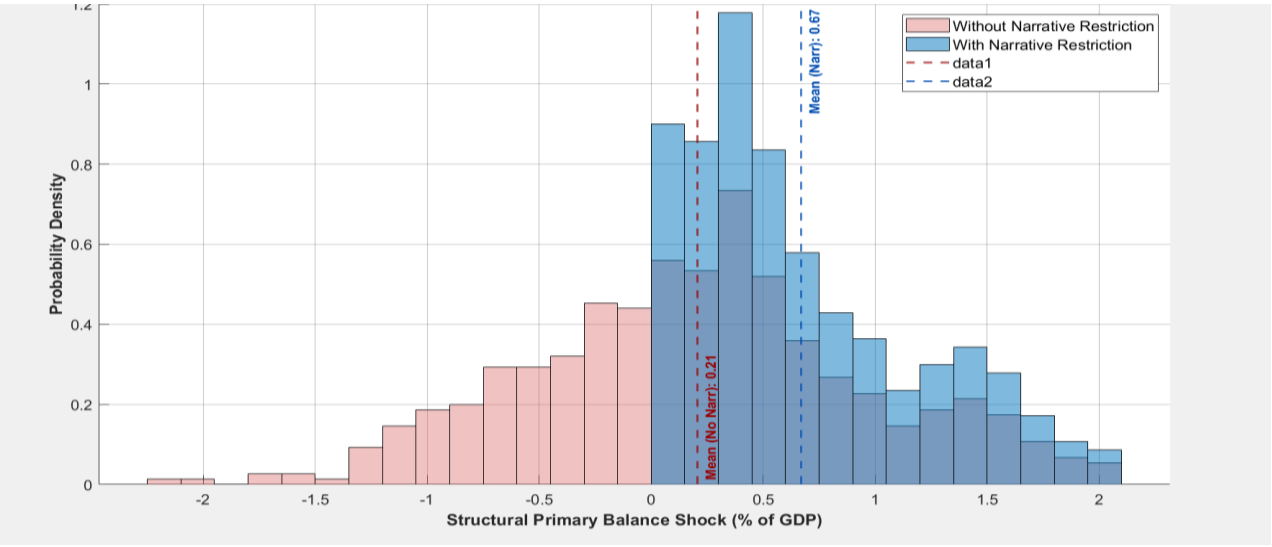

Figure 4.6: Distributional Impact of Narrative Filtering on Primary Balance Shock

Figure 4.6 compares the structural primary balance as GDP percentage with narrative restriction (blue) and without narrative restriction (pink). So, the blue shaded area means that the study has used both the sign and narrative restrictions to identify the exogenous fiscal shocks. It is mostly concentrated around positive shock, between 0 and 1.5 percent of GDP. The mean is around 0.67, highlighted by the vertical blue dashed line, meaning the average shock is much positive and larger, consistent with the deliberate fiscal consolidation. It represents the more plausible exogenous shock as the narrative restriction forces shocks to align with the historical consolidation. Following Diaz and Ramirez (2018), the study found that the narrative information proves to be quite informative even when sparse.

On the other hand, the red bar shows that only a sign restriction is imposed to identify the exogenous fiscal shocks. The distribution is more diffuse, spanning from negative to mildly positive values. So, these shocks are less informative and biased towards the smaller values. They may capture the fiscal behavior driven by the GDP-related policy response or automatic stabilizers. Its mean is 0.21, shown by the red vertical dashed line.

So, the narrative restricted shocks are more informative as they isolate the policy-driven fiscal adjustments like spending cuts, IMF-led tax hikes. Without the narrative restriction, the shocks are contaminated by the business cycle shock. The narrative restriction shifts the distribution rightwards, meaning higher fiscal consolidation, which reduces the noise and improves the interpretability of impulse responses.

Moreover, Figure 4.6 has important implications for Pakistan’s context and policymaking. It is because Pakistan's fiscal policy is highly cyclical and noisy, with spending and taxation decisions frequently responding to short-term macroeconomic pressures rather than the long term (PIDE, 2023), making it harder to distinguish the truly exogenous fiscal shocks. So, by applying narrative

restriction, the study filters out only those primary balance shocks that align with the known fiscal consolidation episodes, like the IMF-supported programs in 2001, 2008, 2013, 2019, and 2023. As highlighted by Diaz and Ramirez (2018), by combining the sign and narrative restrictions, the interpretation of structural shock is enhanced. This method is particularly valuable in Pakistan, given the country's long-standing pattern of reactive, externally anchored fiscal adjustments (Bhowmick, 2025; IMF, 2024).

4.6.2 Impulse Response Analysis: Narrative Constrained Primary Balance Shock

This section presents the impulse response functions derived from the SVAR model identified using the narrative restrictions on the primary balance shock. The narrative restrictions strengthen the shock credibility and exogeneity. The impulse response in Figure 4.7 shows how the macroeconomic variables evolve following a discretionary fiscal adjustment.

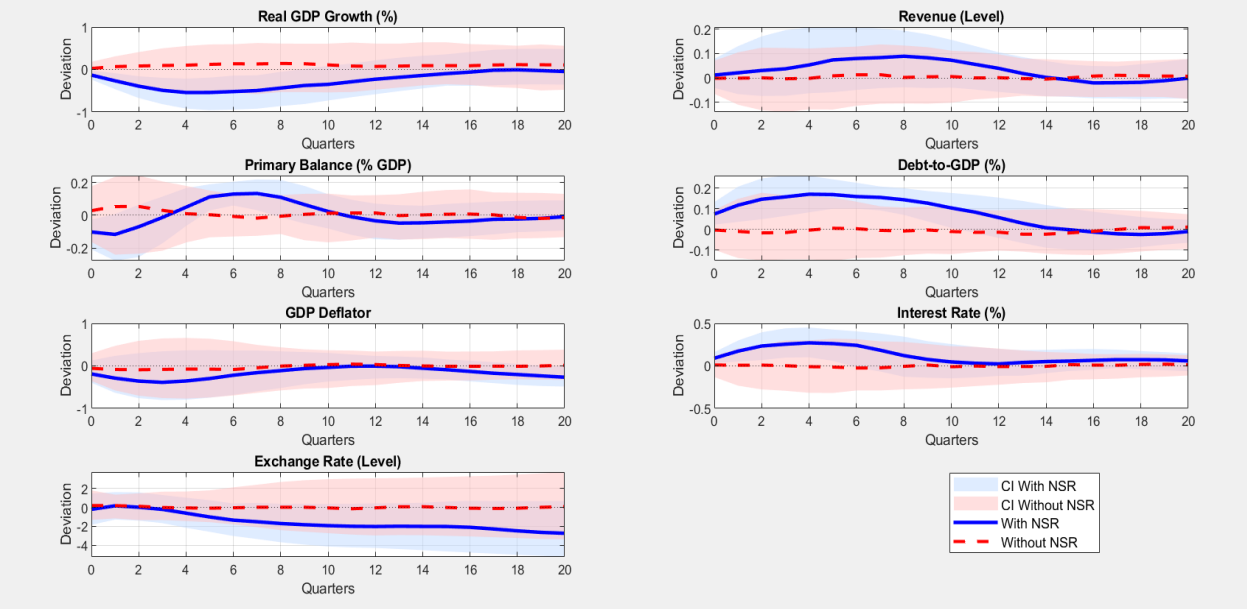

Figure 4.7: Narrative Information Impulse Responses to the Primary Balance Shock

The solid blue line and the shaded area show the impulse response of the variable under the narrative sign restriction, and the solid pink line and shaded area show the impulse response

without the NSR. Consistent with the literature suggesting that the exogenous consolidation tends to have limited contractionary effects (Born et al., 2023; Alesina et al., 2019), the real GDP growth shows a mild negative response. However, without the narrative sign restriction, the response of GDP growth is mildly positive, which might be because of endogenous bias, as the fiscal tightening may coincide with the economic expansion (Ramey, 2016; Gujarado et al., 2014).

Moreover, the primary balance and revenue increase more strongly under the narrative sign restriction, showing the exogenous and the discretionary nature of the fiscal shock as the narrative information captures the policy efforts more efficiently (Diaz and Ramirez, 2018; Arias et al., 2023). On the other hand, the debt-to-GDP ratio under the narrative sign restriction declines modestly, while with no NSR, there is a steeper reduction.

Under the narrative sign restriction, the inflation and the exchange rate respond moderately, indicating a slight increase in the inflation, which might be due to exchange rate pass-through or the tax-driven price effects (IMF, 2022). Under NSR, the interest rate increases more sharply, suggesting a market pricing of fiscal credibility (Ilzetzki et al., 2021). Overall, Figure 4.7 shows how the inclusion of narrative information accurately identifies the discretionary fiscal shocks. The narrative sign restriction improves the isolation of policy-driven movements and avoids confusing them with the cyclical dynamics.

4.6.3 Impulse Response Analysis: Government Revenue Shock

Figure 4.8 shows the impulse responses to a positive government revenue shock. The solid blue line shows the median response, and the shaded area shows the confidence bands. The government revenue increases sharply following the positive shock, validating the identification strategy. The real GDP growth modestly declines in the short run, consistent with the tax-based consolidations' contractionary effects, aligning with the estimates by Khan (2024), which find output losses in the

short run are associated with the tax increase in historical fiscal adjustments in Pakistan. But, the response is not statistically significant as the confidence bands are wide, meaning that while the direction of the response aligns with the theoretical concepts and expectations, the estimate's precision is limited, which might be due to the low number of clean fiscal episodes in Pakistan or due to the data volatility.

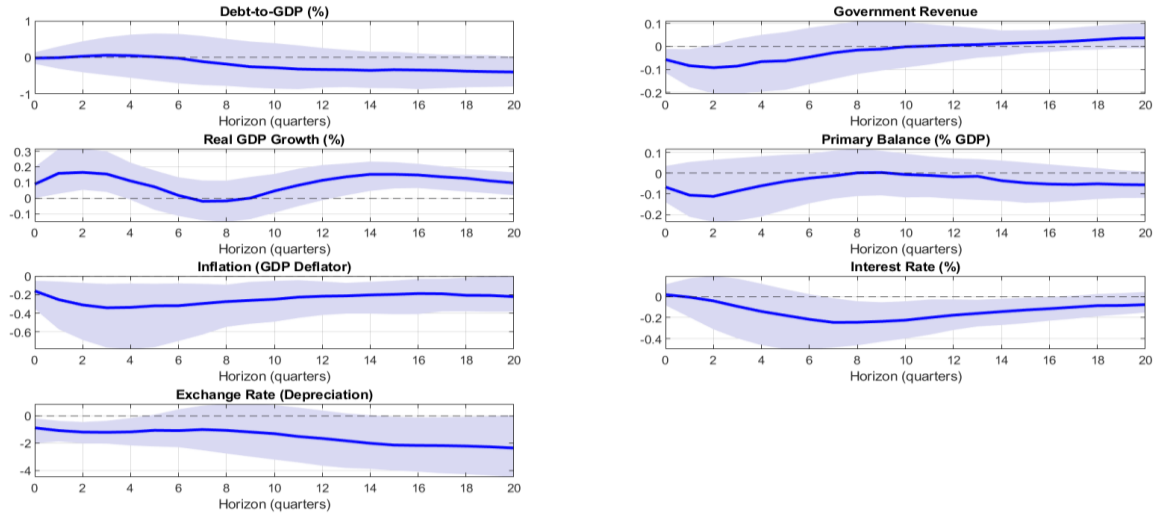

Figure 4.8: Impulse Response to Government Revenue Shock

Moreover, following the positive government revenue shock, the debt-to-GDP ratio declines slightly initially before stabilizing, reflecting the mechanical effect of the better growth, a pattern highlighted in Pakistan's fiscal responsibility and debt limitation act (2005) compliance assessment. However, the interest rate and inflation show a muted response, indicating the limitation of monetary spillover. Lastly, the exchange rate improves mildly, indicating the reduced external financing needs and the improved investors' confidence. These findings align with the Monetary Policy Statement and Decision by SBP (2019 - 2022). In conclusion, Figure 4.8 provides a coherent revenue-based consolidation in Pakistan that tends to be mildly contractionary but is

not strongly destabilizing. The lack of statistical significance in some responses highlights the importance of data quality and fiscal transparency for a more precise structural identification.

4.6.4 Impulse Response Analysis: Narrative Constrained Revenue Shock

This section presents the seven key macroeconomic variables, fiscal responses to the positive government revenue shock in the case of Pakistan, that are identified using the Bayesian structural vector autoregression with the sign and narrative restrictions following the methodology proposed by Mertens and Ravns (2013) and then further confirmed by Patel and Alva (2024). The strategy of identification is based on the restriction that the revenue increase, like the administrative improvements or the tax reforms an impact leading to the lower output, higher government revenue, and reduced inflation. To ensure that the estimated response reflects the plausibly exogenous fiscal consolidations, only the shocks that satisfy the restrictions are retained.

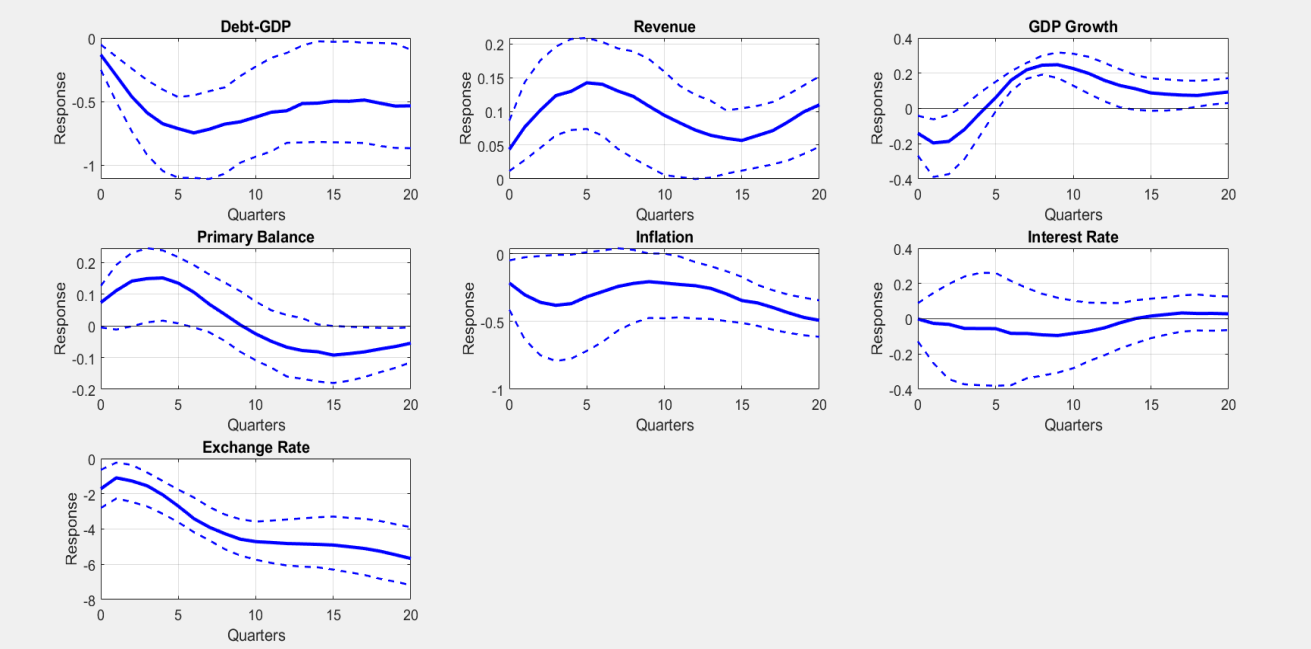

Figure 4.9: Impulse Response to Government Revenue Shock Following Merten and Ravn's

The output shows a clear pattern. As seen in Figure 4.9, the government revenue persistently and sharply increases in response to the positive government shock, validating the identification strategy of the shock. On the other hand, the real GDP growth in the short run improves mildly, but shows a negative response for several quarters, consistent with the contractionary effect of the tax-based consolidations, especially for developing economies like Pakistan (Khan, 2024), where the monetary policy may not fully accommodate the fiscal tightening, and the automatic stabilizers are weak. Moreover, the debt-to-GDP initially declines slightly, likely due to better growth, and stabilizes over time. The inflation also declines modestly, showing that the revenue shock is not inflationary and might even contribute to price stability. However, the response of interest rate is muted, meaning either the limited monetary tightening or the passive policy stance. Lastly, the exchange rate appreciates slightly, reflecting the reduced external financing needs or improved investor sentiments, following a credible fiscal adjustment (SBP, 2022)

Compared to Figure 4.8, in which the broader narrative SVAR approach is used, Figure 4.9 responses are sharper and more statistically significant, highlighting the value of imposing stricter narrative restrictions to isolate the truly exogenous fiscal shocks. The results are consistent with the international evidence, like Patel and Alva (2024), Merten and Ravns (2013), and Mountford and Uhlig (2009), though the multiplier magnitude is somewhat smaller. This also aligns with Pakistan-specific studies Khan (2024), Ara and Sabir (2024), and Malik (2020). This might be reflecting the structural differences in Pakistan's economy, like the lower fiscal credibility, narrower tax base, or the limited fiscal and monetary coordination.

4.6.5 Comparative Analysis of Shock Contributions to Public Debt

Using the two distinct approaches, namely the historical decomposition (HD) and the forecast error variance decomposition (FEVD), Table 4.2 compares the contribution of three identified shocks,

the supply shock, the demand shock, and the primary balance shock, using a Bayesian SVAR model. The forecast error variance decomposition quantifies how much of forecast uncertainty is attributable to each shock, reflecting the relative importance of each shock in driving the debt volatility over a specified horizon. The first column reports the forecast variance median share in debt-to-GDP ratio explained by each shock across the 100 accepted posterior draws over the 20 quarter horizons. In contrast, the historical decomposition column reports the average signed contribution of each shock to the realized path of the debt-to-GDP ratio over the time period 1980Q1 – 2023Q4, reflecting the actual magnitude and the direction of each shock's impact on the debt level.

Table 4.2: FEVD vs Historical Decomposition Contributions to Debt-to-GDP

	FEVD (%)	**Historical (%)**
Demand Shock	27.72	-10.68
Supply Shock	35.11	11.82
Primary Balance Shock	32.35	13.58
Total Identified Shock	95.18	14.73

The outcome of the FEVD technique implies that all three shocks are important sources of forecast uncertainty. The largest share is from the supply side shocks, accounting for 35.11%, followed by the primary balance shock of 32.35% and the demand shock with a value of 27.72%. It suggests that both the fiscal policy surprises and the macroeconomic conditions are the significant drivers of Pakistan's debt volatility, consistent with the recent findings by Ahmed and Afzal (2020) and the IMF (2023), which emphasize both the fiscal sustainability and growth challenges in Pakistan. The total contribution of the identified shocks to the forecast variance is 95.18%, indicating that almost all the systematic variation in debt dynamics is nearly captured by the model.

On the other hand, the historical decomposition tells a more nuanced story. It shows that the primary balance shock contributes positively to the debt accumulation (13.58%), indicating the impact of discretionary fiscal actions, such as spending increases, tax cuts, or delayed consolidations. The supply shock also contributes positively (11.82%), consistent with the energy bottlenecks, the role of inflation, and external shocks in the debt burden (SBP annual report, 2023; Farooq and Sarwar, 2021) However, the demand shock contributes negatively (-10.68%), suggesting that the strong aggregate demand helps in reducing the debt-to-GDP ratio, likely because of improved revenue performance or the higher GDP growth. In conclusion, the primary balance shock is both debt-increasing and volatile, underscoring the fiscal discipline. The supply shocks are influential in both dimensions consistently, highlighting Pakistan's economic structural vulnerabilities.

The gap between the FEVD and HD for demand shock (27.2% vs -10.68%) shows that while the demand shock contribute significantly to the volatility in debt forecast, their net historical effect is debt reducing, that might be due to lower borrowing need or the stronger revenue mobilization during the growth phases, aligning with the narrative presented by Khan and Qayyum (2017) and Mahmood et al. (2022) who states the role of real GDP growth on easing the debt burden through the denominator effects in Pakistan.

Overall, Table 4.2 reinforces the central point that the combination of macroeconomic shocks and the fiscal policy choices shapes Pakistan's debt dynamics. The forecast error variance decomposition (FEVD) outcome emphasizes the need for risk management and the fiscal policy choices, while the outcome of historical decomposition highlights the cumulative impact of past policy actions. Altogether, these results validate the use of a structural vector auto-regression

model with the narrative restrictions for the fiscal analysis as a credible tool in the emerging markets.

4.6.6 Impact of Narrative Filtering on Statistical Precision

Table 4.3 shows the percentage difference in the width of 68% highest posterior density (HPD) intervals for the impulse response functions when the narrative sign restrictions are included in the identification strategy, compared to the baseline that only uses the sign restrictions. The width of an HPD is a measure of the statistical uncertainty; the narrower the band, the more precise the estimates are. Each row corresponds to the macroeconomic variable, and each column shows how the precision of response changes for a given structural shock.

Table 4.3: Percentage Difference in HPD Widths (Narrative vs Only Sign Restrictions)

	Demand Shock	**Supply Shock**	**Primary Balance Shock**
Debt-to-GDP ratio	-34.15	2.31	-27.63
Revenue	-34.8	-14.77	-2.97
GDP Growth	-46.24	-29.65	-30.91
Primary Balance	-36.92	-9.51	-31.46
Inflation	-45.06	-50.61	-22.72
Interest Rate	-40.41	-19.03	-28.36
Exchange Rate	-32.18	-34.85	-13.97

The negative values imply that the inclusion of narrative information reduces the uncertainty; however, the positive values indicate an increase in uncertainty. Although the narrative restrictions were applied directly only to the primary balance shock, the HPD width shrinks across all the variables and shocks, demonstrating the broader precision gains that arise through the joint rotation of the model's structural equations.

The outcome shows that for most of the shocks and variables, the inclusion of narrative restriction leads to the substantial reduction in the width of HPD, even more than 40% in some cases, like the width of HPD in case of GDP growth response to the demand shocks declines by the 46.24%, while the uncertainty around the inflations response to the supply side shock declines by the 50.61%. These values show that with the inclusion of narrative information, there are significant improvements in the statistical precision, meaning that the narrative information sharpened the structural shocks identification (Merten and Ravns, 2013; Diaz and Ramirez, 2018).

In the case of a demand shock, the most consistent reductions are observed, where all the variables under the narrative enhanced specification show the narrower HPD intervals. It is important for the Pakistan case, where, due to the overlapping policy interventions and the data limitations, the demand-side dynamics are often difficult to isolate. For the primary balance shock and the supply shocks, the reductions are also substantial, though slightly more variable. Like the HPD width for the revenue response to the supply shock decreases by -14.77%, while the response of the exchange rate to the primary balance shock becomes more precise by -13.97%. Given the structural volatility of Pakistan's external and fiscal sectors, these improvements are meaningful.

In Table 4.3, there are some positive values, like in the case of debt to GDP response to the supply shock, the HPD width increases by 2.31%. However, these are small in magnitude and are isolated. They might reflect the minor trade-offs in the model flexibility when the additional restrictions are imposed. Moreover, no variables show a consistent increase in the uncertainty across the shock, reinforcing the robustness of the narrative-enhanced identification strategy.

4.7 Analysis and Overall Summary of Results

A consolidated interpretation of empirical findings is provided in this section, weaving together the results from historical decomposition, impulse responses, and comparative assessment of

identification strategies. This section is framed to evaluate the empirical results' consistency with the initial objectives of the study, leading to a clear articulation of the most effective fiscal consolidation mechanism in Pakistan.

Historical decomposition reveals that Pakistan's debt dynamics are asymmetric and are mostly driven by the external and the residual factors rather than systematic fiscal policy. During the debt-increasing period, all identified shocks contributed negatively, meaning they acted to stabilize debt, while the original rise is from residuals like the statistical revisions, below-the-line operations, and exchange rate revaluations. In contrast, during the period of debt decrease, both the primary balance and supply shocks contributed positively, showing that the debt fell despite the fiscal and structural pressure rather than because of them. This suggests that Pakistan's debt reductions are largely opportunistic, occurring under the favorable external conditions, while fiscal policy remains pro-cyclical, amplifying rather than smoothing economic fluctuations.

A key contribution of this thesis is the use and comparison of sign-based and narrative-based restrictions. It shows that the narrative restrictions improve the precision of empirical analysis. Under the sign restrictions, identified fiscal shocks are smaller in magnitude and are more difficult to distinguish from the cyclical adjustments. The incorporation of historical information allows the model to more effectively isolate the exogenous shocks. Figure 4.7 shows that the mean of narrative-restricted primary balance shock is more credible and larger (0.67%) compared to sign restriction only (0.21%). It shows that the narrative information aligns the econometric findings with the actual fiscal history of Pakistan, thereby enhancing consistency with the thesis objectives.

Moreover, the narrative restricted primary balance shock (fiscal consolidation) impulse response provides a nuanced answer, showing that fiscal consolidation reliably reduces the debt-to-GDP ratio, and its impact on GDP is modest, not severely contractionary. This suggests that the credible,

necessary, well-identified fiscal adjustments can reduce the debt without triggering a deep recession, likely through positive confidence effects on the sovereign risk and investment.

The analysis also highlights the three fiscal consolidation mechanisms that stand out to be most effective in Pakistan, each supported by the empirical results. First, the structural revenue mobilization is better than the temporary tax measures. Figures 4.8 and 4.9 show that the positive government revenue shock reduces the debt-to-GDP ratio, without severely contracting GDP, highlighting the importance of improving tax administration and broadening the tax base. Second, expenditure efficiency provides a more growth-friendly path to consolidation. Figures 4.5 and 4.6, impulse responses to primary balance shock, show that the expenditure-driven adjustments stabilize debt with relatively smaller adverse effects on output compared to revenue spending. Lastly, the consolidation credibility can be enhanced by institutional anchoring. The comparison of sign and narrative restriction demonstrates that consolidation embedded in an institutional framework like an IMF program produces more precise, larger, and credible debt reductions. However, Table 3 confirms that without the strong domestic fiscal rules, such gains remain short-lived. So, the findings collectively suggest that the debt sustainability in Pakistan depends on efficient expenditure management, revenue reforms, and institutionally anchored fiscal discipline.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

This thesis analyzes the macroeconomic drivers of public debt dynamics in Pakistan using a structural vector auto-regression (SVAR) model, identified through sign restrictions and narrative restrictions applied to fiscal shocks selectively. The study offers a country-specific perspective on how fiscal and growth shocks have historically impacted changes in the debt-to-GDP ratio, with a focus on distinguishing exogenous movements in the primary balance from those correlated with the business cycle.

The finding reveals that the majority of variations in debt-to-GDP forecasts are attributed to shocks related to growth, specifically supply-side shocks (accounting for 35.1%) and demand shocks (27.7%), which contribute to the forecast variance in debt. Fiscal shocks account for 32.4%. However, when examining the actual changes in debt, a different scenario occurs. The historical decomposition result shows that fiscal and supply shocks contribute positively to debt increase (13.6% and 11.8%), while demand shocks have a debt-reducing effect (-10.7%), consistent with the countercyclical nature of fiscal policy during the growth phase in Pakistan (SBP, 2022).

Moreover, the disaggregation of debt into periods of debt increase and decrease shows that fiscal shocks are dominant during debt-increasing episodes, accounting for a median share of 40.2%, but have a small impact on debt during debt-reducing periods (15.7%). This asymmetry aligns with the narrative that in Pakistan, the fiscal consolidations, often IMF-guided, are less effective in sustaining the downward debt path over time and are more aggressive during the fiscal stress. By contrast, the supply shocks also drive the debt in both the increasing and decreasing episodes of debt (72.5% during debt decrease and 50.4% during debt increase), reinforcing the role of

inflationary pressure and structural inefficiencies in the long-term debt accumulation (Farooq and Sarwar, 2021).

The inclusion of a documented fiscal reforms-based narrative sign restriction provides an important robustness check. Although due to the limited historical clarity around the demand and supply episodes, the narrative restrictions are applied only to the fiscal shocks, their inclusion tightens the credible intervals substantially for impulse response functions (IRFs). The information improvement in precision validates the usefulness of qualitative policy information for enhancing the identification of shock in country-level macroeconomic studies (Diaz and Ramirez, 2018; Giacomini et al., 2022).

The study provides a framework for policymakers to understand how the different macroeconomic shocks, demand side, supply side, and primary balance side, affect Pakistan's debt-to-GDP ratio. The quantification of the relative impact of each shock helps identify which fiscal measures should be prioritized to reduce the debt burden without compromising growth. It also enables targeted interventions, allowing policymakers to focus on the most problematic component and design more effective, shock-responsive fiscal measures that support debt sustainability in the long run.

While this thesis provides a detailed decomposition of Pakistan's public debt into its key components and analyzes its macroeconomic implications using the Bayesian SVAR method, it does not explicitly address the issue of debt sustainability. The analysis focuses on the structural and cyclical behaviors of the debt variable, but does not evaluate whether, in the long run, the current debt trajectory is fiscally sustainable. Incorporating sustainability metrics, such as thresholds and intertemporal budget constraints, was beyond the scope of this research, but it remains a valuable direction for future studies.

Policy Recommendations

The following policy actions are recommended based on empirical findings of this thesis to improve Pakistan's debt management and sustainability:

1. **Broaden and Strengthen the Revenue Base**

- Impulse responses to revenue shock show that the sustained revenue improvement reduces the debt to GDP significantly with lower output cost.
- Expand the direct taxation by bringing the retail, service, and agriculture sectors into the tax net. Reduce reliance on indirect taxation, which distorts the consumption and disproportionately affects low-income households.
- Improve compliance through stronger enforcement and digital tax administration.

2. **Enhance Expenditure Efficiency**

    - Primary balance shock shows that expenditure-driven consolidation reduces debt while imposing relatively mild output losses compared to revenue side adjustments.
    - Free up the fiscal space by rationalizing untargeted subsidies. Moreover, reduce the non-productive current spending and redirect the resources towards growth-enhancing public investment.
    - Protect the development expenditures and social safety nets to avoid the negative distributional and growth effects.

3. **Institutionalize Fiscal Rules and Anchors**

    - The comparison of sign and narrative restriction shows that the IMF-backed policies are more helpful in reducing debt compared to sign-restricted policies. However, the historical decomposition result shows that the effects fade without domestic anchors.

- Introduce the binding fiscal rules, like a ceiling on fiscal deficit and public debt. To reduce the pro-cyclical fiscal policies, embed the rules in the medium-term fiscal framework.
- Monitor compliance and enhance credibility by establishing an independent fiscal council.

4. **Develop Countercyclical Fiscal Buffers**
    - Historical decomposition result shows that fiscal shocks are asymmetric, large during debt surge but limited during debt decline, indicating Pakistan's reliance on crisis-driven adjustments.
    - Save revenue windfalls, like from remittances or commodity booms, by creating a stabilization fund. Strengthen the automatic stabilizers, like targeted cash transfers, to reduce the need for abrupt IMF-driven consolidations.
    - Ensure fiscal policy is forward-looking, preparing for a downturn rather than reacting to crises.
5. **Improve Monetary Fiscal Policy Coordination**
    - Align the fiscal consolidation efforts with the monetary policy to avoid overreliance on the interest rate hikes that increase debt servicing.
    - Stabilize inflation and exchange rates while managing the debt pressures by adopting coordinated strategies.
    - Reinforce credibility and investors' confidence by using a joint policy communication.

6. **Institutionalize Fiscal Transparency and Narrative Databases**
    - Narrative restrictions significantly narrowed uncertainty in identified shocks, proving the value of historical fiscal record for policy credibility.
    - Establish a centralized archive of fiscal measures, budget, IMF programs, and reforms.
    - Improve transparency and accountability by ensuring public access to fiscal data. Facilitate the future empirical research and evidence-based policy making through accessible narrative data.
7. **Promote Growth-Friendly Consolidation**
    - Favor policies that stabilize debt while supporting economic growth, like infrastructure investment, tax base broadening.
    - Avoid contractionary, one-off austerity measures that give relief for a short time but undermine long-term debt sustainability.

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Appendix A

Data Transformation and Validity Tests

The original annual data set, although it contains sufficient observations for the standard SVAR estimation (1980 – 2023), the Bayesian SVAR employed in this thesis, particularly under the narrative sign restriction, requires a substantially larger number of observations to generate the effective accepted posterior draws. During the use of annual data, the SVAR model consistently failed to accept the sign restriction criteria, with nearly zero accepted posterior draws, hence generating the flat impulse responses. This indicated that the annual data lacked the temporal granularity needed to support the robust inference under the imposed prior and identification scheme. So, the annual data were interpolated to quarterly frequency, thereby increasing the number of observations to 176 and enabling the model to converge with the valid posterior distributions and produce interpretable impulse responses. Appendix A presents the diagnostic tests used to validate the application of cubic spline interpolation for quartering annual macroeconomic data, ensuring the smoothness, statistical integrity, and economic plausibility of the transformed data.

A.1 Data Consistency and Missing Value Test

It is used to verify the completeness and temporal alignment of the dataset.

Table A.1: Data Coverage and Completeness Summary

Annual Data Range	1980 to 2023 (44 Observations)
Quarterly Data Range	1980 Q1 to 2023Q4 (176 observations)
Missing Values	None detected across all variables

The dataset is based on an uninterrupted and consistent time frame from 1980 to 2023, with 44 annual observations and 176 quarterly post-interpolation observations. No missing values across the dataset of all variables are observed, confirming the reliability and completeness of both the

original and transformed datasets. It ensures that the quarterly series are suitable for econometric modeling, strengthening the foundation for the Bayesian SVAR estimation and the subsequent policy analysis.

A.2 Descriptive Statistics Comparison Test

It is to compare the statistical properties of annual and quarterly interpolated data.

Table A.2: Descriptive Statistics

Variable	Annual Mean	Quarterly Mean	Annual Std Dev	Quarterly Std Dev
Debt-to-GDP	56.1341	56.2153	9.6629	9.2715
Total Revenue	15.1614	15.1375	1.9371	1.8853
Real GDP Growth	4.6500	4.6250	2.1044	1.8413
Primary Balance	-1.3455	-1.4324	1.8714	1.7493
GDP Deflator	9.0295	9.1886	4.9276	4.9082
Interest Rate	13.0455	13.1114	3.0030	3.0127
Exchange Rate	69.9568	66.7943	59.6241	55.7261

The mean and Standard Deviation of annual and quarterly data closely align, confirming that the interpolations preserve the statistical properties of the original data.

A.3 Temporal Aggregation Test

This test assesses whether re-aggregated quarterly data matches the original values.

Table A.3: Aggregation Test Metrics

Variable	RMSE	MAE	Correlation	Bias
Debt-to-GDP	1.0036	0.7199	0.9950	-0.0812
Total Revenue	0.3702	0.2841	0.9813	0.0239
Real GDP Growth	0.9283	0.6727	0.8986	0.0250
Primary Balance	0.6908	0.4449	0.9289	0.0869
GDP Deflator	1.5418	1.2636	0.9495	-0.1591
Interest Rate	0.8293	0.5864	0.9609	-0.0659
Exchange Rate	6.3073	3.4273	0.9974	3.1625

High correlation and the low error metrics show that quarterly data, when aggregated, retains the fidelity to annual benchmarks.

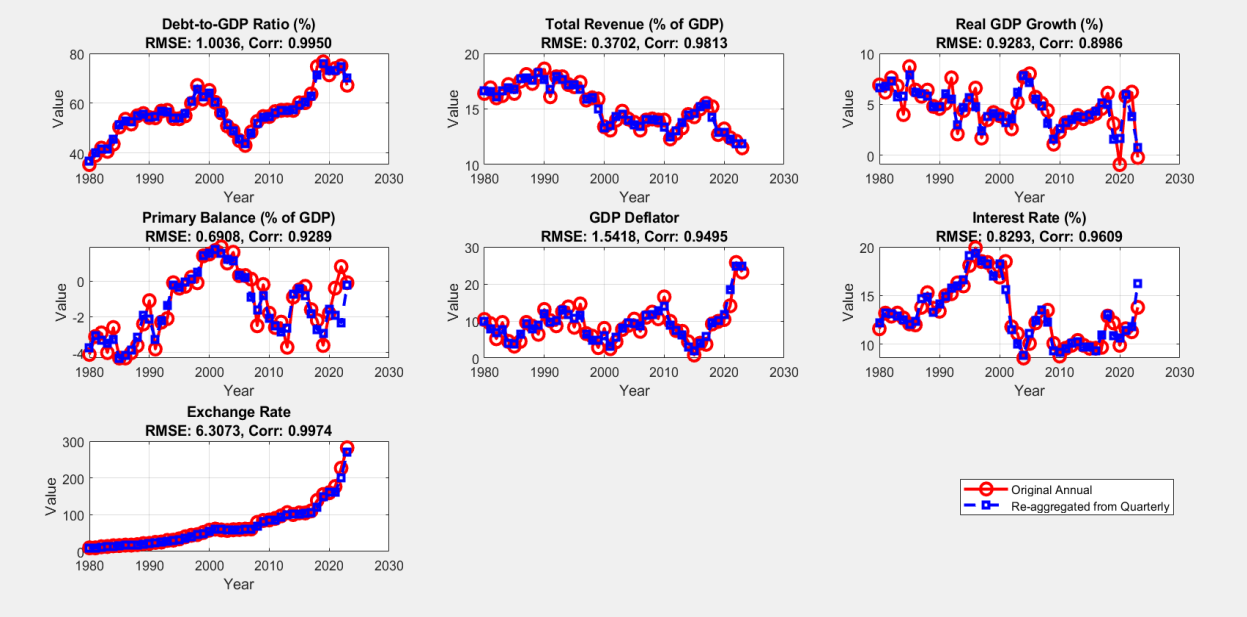

Figure A.1: Temporal Aggregation Test: Original vs Re-aggregated Annual Data

Figure A.1 presents a visual representation of the original annual data and the annual data re-aggregated from the quarterly data across key macroeconomic indicators. Each subplot includes the metrics of root mean square error (RMSE) and the correlation coefficients (Corr). The consistently high correlation and low RMSE across variables indicate that the re-aggregated data closely approximates the original annual series, confirming that the cubic spline interpolation method preserves the economic patterns and does not introduce a significant distortion.

A.4 Smoothness Test

This test is to detect the artificial volatility during interpolation.

Table A.4: Second Difference Metrics

Variable	Mean 2nd Diff	Std Dev	Max Abs Diff
Debt-to-GDP	-0.0161	0.4653	2.2000
Total Revenue	0.0006	0.2027	1.0000
Real GDP Growth	0.0052	0.5189	2.7000
Primary Balance	0.0006	0.2799	1.2000
GDP Deflator	0.0046	0.8646	3.6000
Interest Rate	0.0011	0.3573	1.8000
Exchange Rate	-0.0034	6.9497	54.9000

In Table A.4, the mean difference for most variables is close to zero, and the standard deviation is modest, indicating a stable transition across quarters. The maximum absolute second difference is also within a reasonable bound, supporting that the data is not erratically jumping between the quarters. However, the exchange rate stands out with a high standard deviation and the maximum absolute difference, but it is interpreted as real economic shocks rather than the interpolation error. It is because the exchange rates are more volatile than the fiscal aggregates.

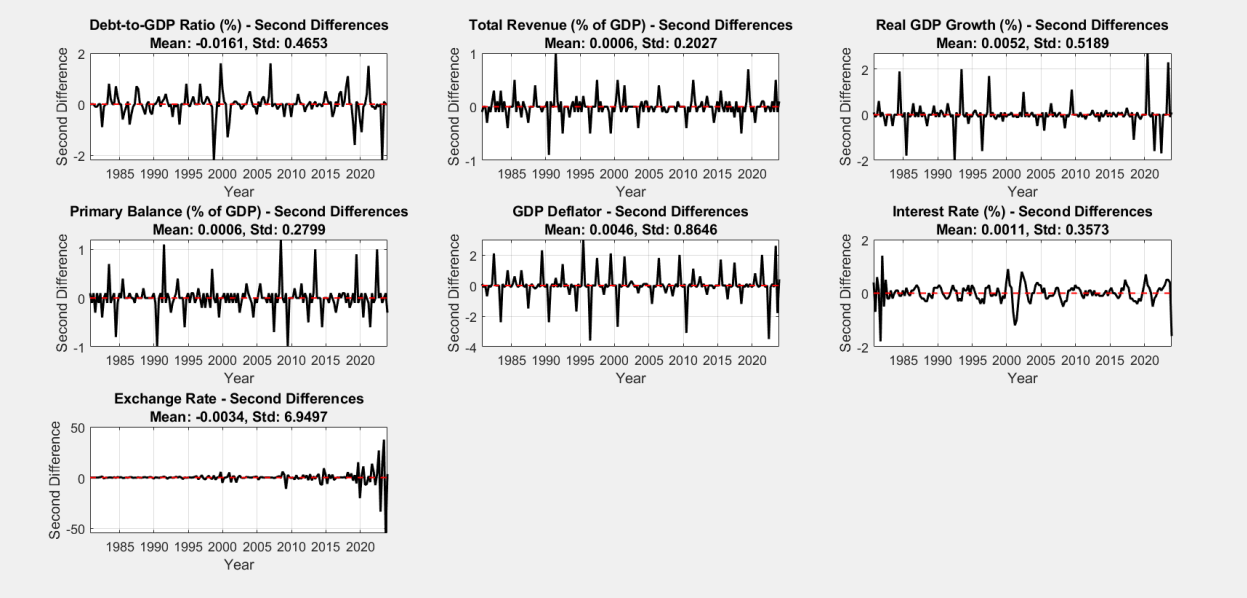

Figure A.2: Smoothness Test, Second Differences of Quartered Series

Figure A.2 shows that most of the variables are centered around zero with low standard deviations, meaning that cubic spline interpolation has produced smooth and stable quarterly transitions, supporting the pre-estimation validity of quartered data. However, the exchange rate shows a relatively large standard deviation and spikes in the second difference, reflecting macroeconomic shocks and external pressures rather than the interpolation error.

A.5 Residual Analysis Test

This test is to assess how well the Q4 values approximate the annual benchmark.

Table A.5: Residual Metrics

Variable	Residual Mean	Residual Std Dev
Debt-to-GDP	0.3523	1.4474
Total Revenue	-0.0545	0.7500
Real GDP Growth	-0.0636	1.8718
Primary Balance	-0.0477	1.0283
GDP Deflator	0.2886	3.0843
Interest Rate	0.1114	1.6038
Exchange Rate	-0.6523	2.0756

The residuals are small and centered around zero, showing that Q4 is a valid proxy for annual data.

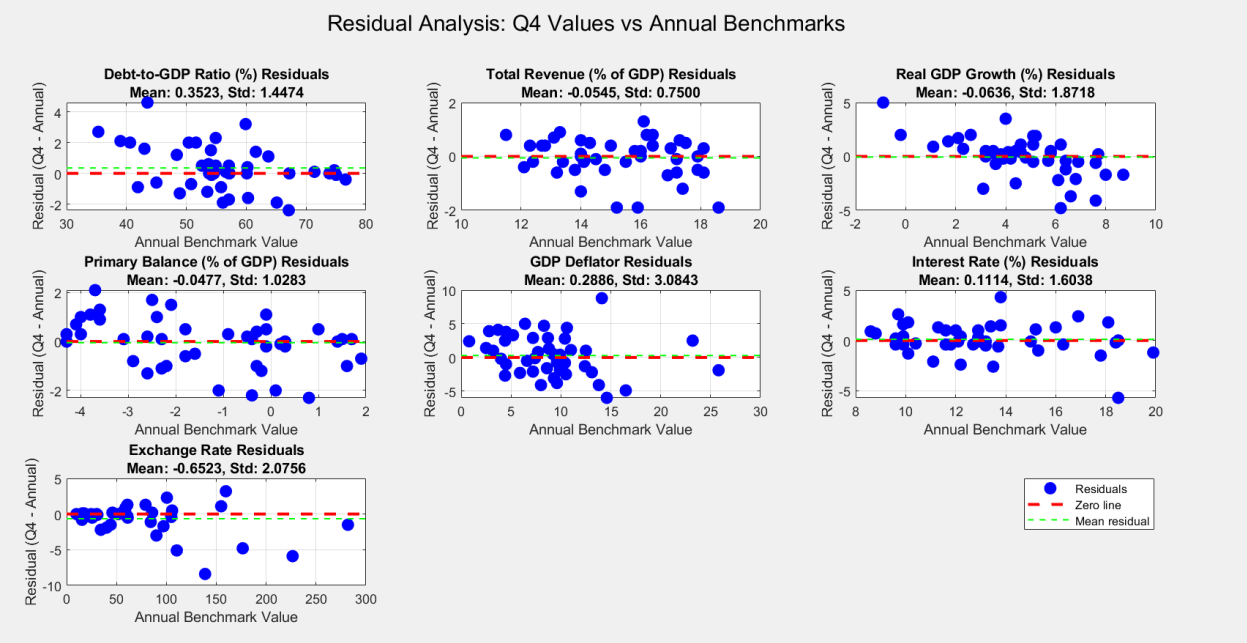

Figure A.3: Residual Analysis: Q4 Values Vs Annual Benchmarks

Figure A.3 shows the residuals between the interpolated Q4 values and their corresponding annual benchmarks. This test is to evaluate the post estimation fidelity of the quartered data, whether the final quarter of each year aligns closely with the actual annual data it is meant to approximate. Each plot shows the residuals along with two reference lines, a red dashed line at zero and a green dashed line indicating the mean residual. The proximity of residuals to the zero line and the tight clustering around the mean line show that the quartered data maintains

consistency with the annual benchmark. Meanwhile, the exchange rate series shows a higher dispersion, given its inherent sensitivity and volatility to external shocks.

A.6 Economic Plausibility Test

This test is to identify any economically plausible values in the quartered data.

Table A.6: Outlier Detection

Variable	Outlier Count
Debt-to-GDP	0
Total Revenue	0
Real GDP Growth	0
Primary Balance	0
GDP Deflator	7
Interest Rate	0
Exchange Rate	3

In Table A.6, most of the variables show no implausible values. However, the outliers in GDP deflator and Exchange rate reflect the genuine macroeconomic shocks.

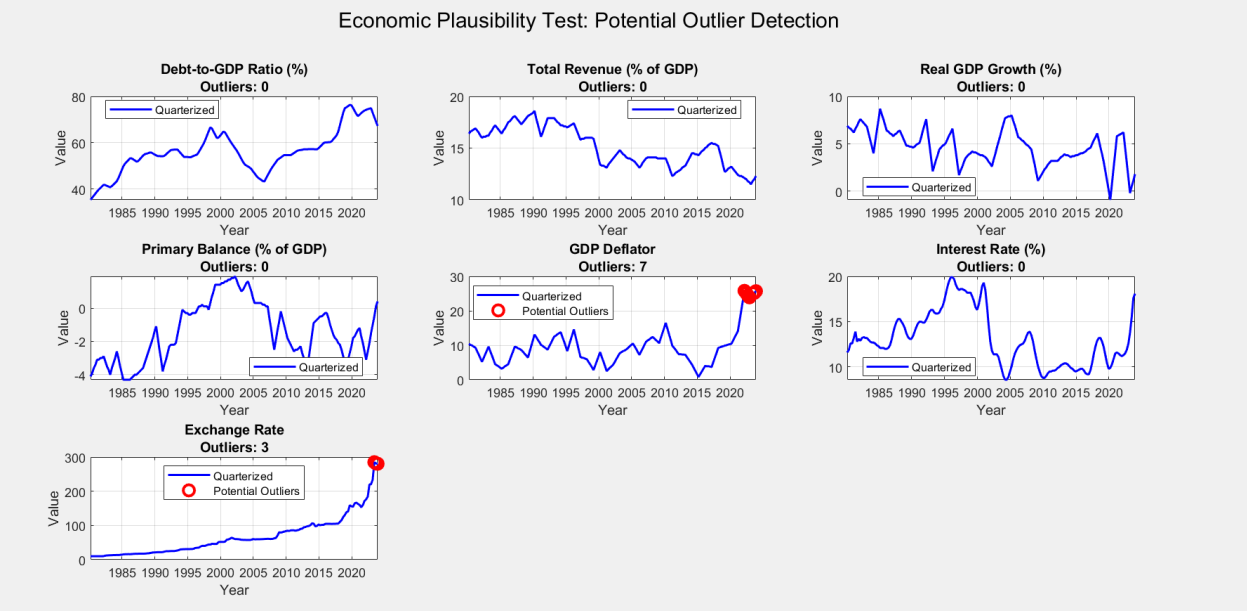

Figure A.4: Economic Plausibility Test: Potential Outlier Detection

Figure A.4 presents a visual representation of macroeconomic series to assess the economic plausibility by identifying the potential outliers to ensure that interpolated quarterly data does not

produce values that are statistically extreme or economically unrealistic. All variables show smooth trajectories with no detected outliers. However, seven potential outliers between 2005 and 2015 are detected, reflecting an inflation volatility period, and three outliers are detected in the exchange rate, likely reflecting genuine macroeconomic shocks.

A.7 Comparison of Annual VS Quarterly Data

Figure A.5 visually demonstrates the annual and quarterly data.

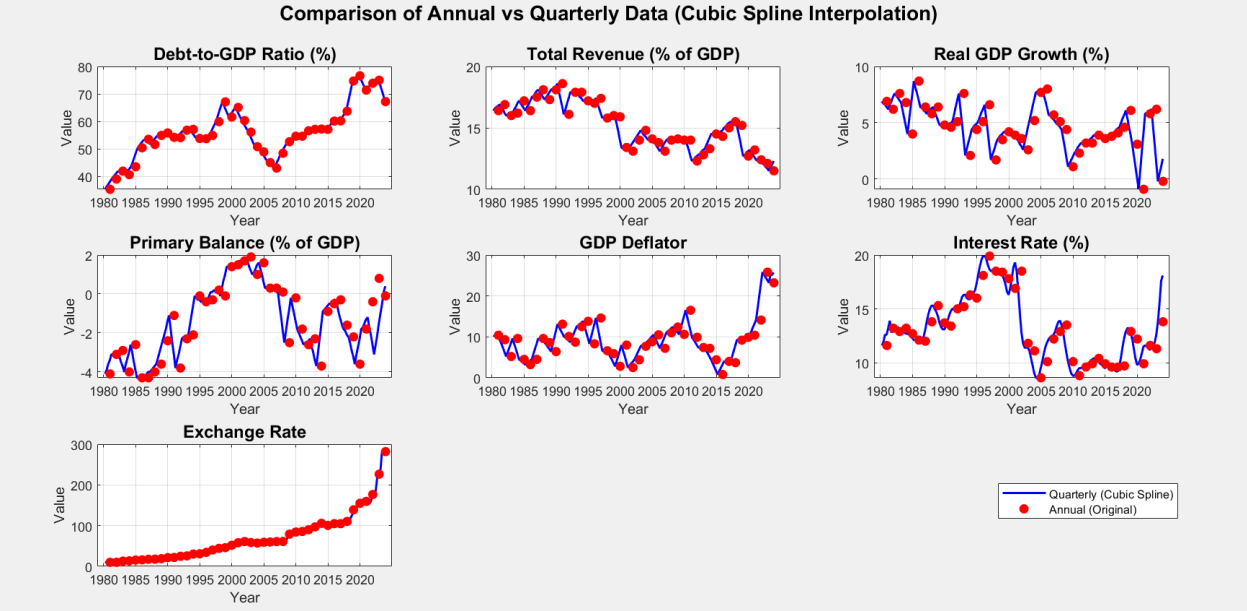

Figure A.5: Visual Representation of Original Annual VS Quarterly Interpolated Data

It illustrates the alignment between the original annual observations (red dots) and the interpolated quarterly values (blue lines) across the seven macroeconomic indicators. The smooth transition and close adherence to the annual benchmark support the statistical integrity and plausibility of the quarterization process.