QUANTIFYING THE SUSTAINABILITY OF PUBLIC DEBT

Time-Varying Evidence from a Developing Country

Cansın Kemal Can
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To Our Mothers

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[1] This book is the published version of the author's Hacettepe University doctoral thesis.

INTRODUCTION

The developing countries like Turkey mostly have long histories of economic instability induced mostly by indebtedness and malfunctioning fiscal policies. In particular, frequent unfavourable movements in the public debt dynamics are among the most profound hindrances to economic development in those countries. Thus, to offer fiscal policy recommendations for those countries, proper scrutiny and investigation of the disruptions in the fiscal policies and underlying grounds for the public debt fluctuations are crucial for reducing the excessive upward movements in the public debt so as to establish fiscal sustainability. Therefore, it is the very purpose of this book to implement a technical appraisal of this sort to contribute to the literature by gauging the degree of Turkish public debt sustainability in a historical perspective to comprehend the past trajectory of the indebtedness and offer caveats to avoid future challenges.

Is there a practical way of quantifying the sustainability of public debt? Is the current public debt sustainable in Turkey? Has the public debt always been sustainable in Turkey during the near economic history, or are there episodes of fiscal sustainability? Based on the findings related to the past and current status of public indebtedness, are there any alarming issues that raise concerns about the future trajectory of public debt in Turkey? These are some of the questions which were attempted to answer in this book. Nevertheless, the techniques used for the analysis can be adapted to other developing country data as well.

In order to find answers to these questions in various levels of stringencies, a special form of the fiscal reaction function was estimated in different settings in this book, including the time-varying setup. Succinctly speaking, this function tests the existence of sufficient fiscal reaction in the form of primary balance generation to establish and preserve the sustainability of public debt, which constitutes a practical way of concretizing and quantifying the rather ambiguous concept of public debt sustainability.

One of the interesting findings of the time-varying analysis is that sustainability has been achieved through a fiscal transformation, but it did not exist in each sub-periods of the near economic history in Turkey. Also, another noticeable point to make is the heightened concerns about the near future based on the worrisome pattern of parameters. The time-varying estimation indicates a downward movement in the fiscal reaction parameter, potentially jeopardising public debt sustainability in the following years.

In view of these arguments, this book's primary motivation is to enrich the academic literature on public debt sustainability in developing countries by introducing a time-varying fiscal reaction function using Turkish data.

The book is developed under three chapters;

The first chapter discusses the theoretical issues related to public debt sustainability. It sheds light on the relevant terminology and formal derivations of the model's underlying equations. This chapter also goes into the consequences of a failure in reacting to rising public debt appropriately. The chapter also covers the extent to which the government's fiscal reactions can be performed and how the timing of responses can be determined, and why they are essential. In short, the first chapter can be thought of as an overture to the fiscal reaction function.

The second chapter is devoted to the review of the related literature. The theoretical and empirical contributions to the subject are evaluated in this chapter to comprehend the current status of the literature on which the analyses of the book are grounded to make the academic contributions more distinguishable. This chapter also discusses the alternative models which could have been used instead of the fiscal reaction function, examines their pros and cons and evaluates how the fiscal reaction function outperforms them in concretizing the analysis of public debt sustainability. This comparison provides the rationale for preferring the fiscal reaction function over the other models as a public debt sustainability analysis tool.

The third chapter deals with the empirics of the subject. Along with the design and implementation of the empirical analysis, this chapter also introduces the data and its distinctive properties and a brief outline of Turkey's economic history in the last fifty years to facilitate the interpretation of the empirical findings. The chapter also briefly introduces the econometric techniques used for estimation and ends with a discussion of the empirical results.

Lastly, the final part provides an overall conclusion. It gives some cautions about the potential risks associated with Turkey's future public debt sustainability based on the empirical findings derived in the third chapter.

CHAPTER ONE

THEORETICAL ISSUES REGARDING PUBLIC DEBT SUSTAINABILITY

This chapter aims to briefly consider the key concepts and definitions pertinent to public debt sustainability along with the discussion of some other relevant topics. Some derivations of debt dynamics that guide the book's methodological part are also included within this chapter. In addition to that, the chapter also discusses the costs and dangers associated with high and unsustainable debt.

For this purpose, it is worthwhile to start with the definition of debt and continue with outlining the meaning of public debt sustainability from academic as well as pragmatic perspectives. The key concepts to be discussed include solvency, debt overhang, doom loop, adjustment fatigue, fiscal space, snowball effect, Ponzi scheme, transversality condition, intertemporal budget constraint etc.

Besides, this chapter also provides an introduction to the fiscal reaction function. The underlying algebra of the indicated function is analysed in this section which facilitates the comprehension of the results in the empirical section. Moreover, this chapter clarifies the distinction between solvency and sustainability. These two terms are frequently used interchangeably in the literature; however, solvency is only a prerequisite for sustainability, and sustainability is a far broader concept.

Finally, the chapter covers the shortcomings and limitations of the debt sustainability framework.

1.1 An Appraisal of Debt Sustainability Concept and its Importance

This section purposes to transform the rather vague concept of debt sustainability into a more concrete and clear-cut notion. Due to the opaque character of the concept, the theoretical and operational definitions of public debt sustainability are abundant in the literature. The inconsistency between the statistical and academic definitions of the concept and the existence of various alternative definitions make real-world sustainability assessments more arduous. Taking these challenges into account, the purpose of this section is to outline the concept of debt sustainability and some other relevant terminology in order to present the background required to comprehend the econometric estimation results in the third chapter.

1.1.1 Defining the Public Debt Sustainability

Throughout economic history, borrowing has been an inevitable source of financing by enabling the countries to finance public needs beyond their budgetary capacity since they have scarce financial resources compared to the size of the society's financial needs. Long-run infrastructure investments, for instance, are mostly financed through borrowing as they require a significant amount of funding. Also, borrowing allows the cost of borrowing to be borne by the next generations who will, to a large extent, reap the benefits of such long-term investments.

However, despite its beneficial aspects, borrowing can also have impairing effects on the economy when used abusively by the fiscal authorities. The deteriorating effects of public debt get even harsher if the government fails to implement proper financial management strategies to prevent it from reaching unrepayable levels compared to governments' capacity to pay. Thus, it is quite an essential task for governments to monitor their existing borrowing and design their future financing needs wisely and thoroughly. The normative judgements about the debt profile will be misleading in the absence of descriptive monitoring of debt realizations and associated fiscal policy reactions. Yet, misleading arguments related to debt management might beget devastating outcomes in the future as they will lead to wrong policy choices. For this reason, a proper and firm grasp of the term needs to be acquired so as to implement debt sustainability appraisal appropriately.

Public debt can very briefly be described as an obligation of the government to make return payments to the debt holders. The government acquires the command over the financial source for a certain period until redemption. In exchange for this right, the government promises to make payments at a particular date in the future. These payments generally include an interest payment as well. The debt holder can resell the bonds in the secondary market or wait until the maturity date. The length of the maturity period determines the liquidity of the debt, and the shorter the maturity term, the more liquid the securities become. The array of debt portfolio is oftentimes quite significant since the government borrows in various maturities. The government can shorten this period by repurchasing the stakes in the market or wait until the date of payoff (Buchanan & Wagner, 1967, pp. 3-4). Literally, debt is permanent and inevitable for every country. However, the real problem is not the existence of the debt but the perpetual need to roll over the debt accumulation. The difficulties regarding public debt management occur when the existing debt matures, forcing the government to find new financing sources. The exigent financing required for continuous social expenditures is a major source of the debt management problem, and if prolonged, it leads to debt sustainability concerns. Retiring or reducing the existing public debt is not a permanent solution to the debt management problem. The country will still have to acquire extra financial resources to refinance the remaining debt and make expenditures beyond the budgetary capacity.

Besides debt reduction, the government can also alter the maturities of the existing debt; however, even then, the debt-induced management problems might keep appearing in the economy. The government can indeed employ several techniques to reduce the detrimental effects of malfunctioning debt management, but the point here is that regardless of the existing amount and the maturity structure of outstanding debt, the government has to service the debt on a continuous basis. Failing to do so brings about debt sustainability problems.

Thus, rational debt management is a principal requirement for modern economies. However, outlining the causes and consequences of public debt's unsustainability and portraying the boundaries for the phenomenon is quite a challenge for theorists as it has a very multi-faceted nature (Wyplosz, 2011, p. 4). Moreover, one of the most displeasing and a rather intrinsic issue relevant to the public debt sustainability analysis is the lack of any cut and dried operational definition of debt sustainability in the literature (Chalk & Hemming, 2000, p. 3). This weakness of the concept hinders the provision of normative guidance as the scope for the judgement is considerably large (Debrun, 2015, p. 2).

In fact, the vagueness of the term debt sustainability originates from the lack of a proper definition of the term *sustainability*. Generally speaking, the concept of sustainability inherently refers to the processes which are maintained for long periods. The word "maintain" presumably reveals the intuition behind sustainability. Using this analogy, it is safe to conclude that public debt sustainability is, to a large extent, related to preserving (or maintaining) the value or the composition of debt throughout a large time span (IMF, 2011, p. 6). According to Salsman (2017), the sustainability of the public debt is the government's capacity to borrow prudently and affordably to provide public goods and services without sacrificing its sovereignty or the rights, liberties, and prosperity of citizens.

In the literature, economists have numerous other attempts to define debt sustainability, but none of them has been universally accepted thus far. Part of the reason for the lack of a clear-cut description of public debt sustainability is that for most of the history of economic thought, the solvency rather than sustainability of the debt has been the popular term to discuss among economists. Nevertheless, even though these two terms are closely linked, solvency is not a prerequisite for sustainability. An insolvent policy might still give rise to sustainability, provided that the government is capable of altering policies accordingly. As a result, commitment and policy reversal capabilities are crucial for a solvent government to have a sustainable fiscal policy (Horne, 1991, p. 2).

Another reason why there is no clear-cut definition of public debt sustainability is the complexity within the scope of public debt profiles of modern economies. In modern economies, the magnitude of the debt is not as critical as the credibility of the country since the latter allows for a more comprehensive comparison among countries, unlike the former. Also, many economies in the world have a sizeable amount of contingent liabilities that are very difficult to measure and far above their outstanding assets. Contingent liabilities are postponed borrowing for the government, and similarly, public debt can be thought of as postponed taxation. The existence of such contingent liabilities makes debt management more difficult to control. Hence, the implicit leverages of most countries are far below their explicit leverages. As a result, effectively, the debt structure of a country appears to be far more complicated than what mainstream theories suggest.

In economic history, the theorists had primarily concentrated on the government's solvency rather than debt sustainability. The Keynesian paradigm, for instance, gave rise to radical departures from the classical view in public financial management as far as solvency was concerned. An important milestone in this respect was obviously the Great Depression in the 1930s, which led to the collapse of all the postulates of the classical view. After the recession, the income-generating properties of the debt were more prominently revealed by Keynesian economists.

The Great Depression transformed the economic view profoundly and, in a way, characterized the modern fiscal policy framework. In the aftermath of this recession, Keynesians impinged on the Classical view from various aspects. For example, instead of perceiving the debt as a burden on the economy, the new idea was to see it as an overall asset of the entire nation. According to this new paradigm, during harsh recessions, the borrowing could reignite the economy if the borrowed funds are conveyed to the real economy through heightened public expenditures.

In addition, unlike Classics, Keynesians advocated deficits in the budget as it allowed the government to make extra spending, which could stimulate the economic prosperity in the country. Through an unbalanced budget, financial resources higher than the budgetary capacity could be diverted to the real economy by the government via their fiscal policy tools to stimulate the effective demand in the overall economy. In other words, insolvency (but not unsustainability) is in a way recommended by Keynesians, let alone refrained from (Buchanan J, 1999, pp. 94-97). Among these fiscal policy tools, debt instruments were particularly proposed to absorb excess funds during a boom and to pump liquidity into the economy during a recession (Salsman, 2017). Consequently, according to this view, the overall size of the debt is not essential for sustainability considerations. In fact, what matters is the capacity of the country to service the public debt without being highly indebted in the long run. In other words, this modern theory emphasizes the importance of the income-generating potential of the economy rather than the existing amount of public debt.

1.1.2 Why is Public Debt Sustainability Important?

One of the critical consequences of persistently high public debt is the potential vulnerability to sudden stops of financial flows as high debt leaves the country unguarded against financial risks and unfavourable economic events. Inflows of funds into the country can stop abruptly for various reasons, including shifts in global risk preferences or an adverse shock originating from international markets. Especially for developing countries that need excessive external financing, such an instant halt in the financial flow can have impairing effects as the economy effectively demands continuous international finance to roll over the existing debt. Most of the time, such stops materialize very swiftly, and the country is often caught off-guard. These sudden stops can be so severe that they might even lead to an outflow of existing capital by reducing the sovereign credit rating. The decline in this rating, in turn, might potentially have a permeating impact on the country as a whole, such as capital account restrictions, drastic cuts in public expenditures, currency crisis, banking crisis, recession and even a default (Eichengreen & Gupta, 2016, p. 3).

Along with the above-mentioned scenario, a sharp upswing in the risk premium of the economy brings about a substantial surge in the interest rate, which can crowd out the private investment. In addition to that, from a public finance perspective, when the debt level is already high and unsustainable, the government falls short of adequate fiscal space in the case of a downturn. As the debt level is currently high, the government loses the flexibility to increase the expenditures when it needs to implement fiscal policies for social purposes. The result of the above-mentioned scenario is usually a *"debt overhang"*. It is the situation where the expected tax burden arising from the existing level of debt is so high that the investors no longer have the willingness to perform new investments as they are concerned about potential default of the country (Sachs & Huzinga, 1987, p. 41). In this case, the consumers face a disincentive to increase their consumption for the same reason, and the result will be a drag on economic activities. In this case, the economic actors perceive the creditors as the sole benefiter of the upcoming stream of primary surpluses. Being the sole bearer of the costs of harsh policy adjustments, they have a high reluctance to make new investments, thereby boosting economic activity since the loss will be inevitable and the expected tax payments will be considerably increased.

Consequently, the decline in investments gives rise to lower economic growth and consequently to lower government revenues. The end result of this process is an insufficient amount of funds for the social and economic functions of the budget. Under these circumstances, the concerns about the default in the country rise with a higher risk of insolvency because the way the government will be able to finance itself becomes questionable. These circumstances create a vicious circle between low growth, low revenues, higher borrowing needs, higher risk of default, and lower investments (Krugman, 1989, p. 6).

As a result, economic activities plunge and fiscal balances deteriorate dramatically. In other words, the contagion of an economic downturn in specific sectors of the economy eventually leads to debt sustainability problems in the economy. In addition to this, the spillover effect echoes back to the private sector via channels of the higher risk premium and lower credit ratings of the sovereign. Thus, to avoid such an unpleasant sequence of economic events, monitoring the sustainability of the public debt thoroughly is crucial from the economic stability perspective.

1.2 A Prelude to Fiscal Reaction Function

Now that the importance of public debt sustainability and the associated potential problems have been clarified, the next step is to choose an appropriate tool to scrutinize the existence of fiscal sustainability. The fiscal reaction function comes into play at this point. Simply, this function gauges the strength of the reaction pursued by the fiscal authorities when the debt level moves away from its sustainable path. In other words, this function tests the strength of the primary surplus reciprocations to debt realizations.

For the purpose of comprehending the logic behind this function, the underlying mechanism of debt dynamics needs to be evaluated in detail. The objectives of exploring those mechanisms are twofold: The first objective is to reach the debt dynamics by which the debt evolves over time. The second objective is to formulate the formal solvency condition. To accomplish these objectives, another variable, namely the primary balance, is incorporated into the analysis so as to reveal the nexus between debt and deficit. This new term can be defined as the difference between non-interest revenues and non-interest expenditure. This indicator measures the influence of current fiscal policies on the indebtedness of the country. The interest reimbursements occur due to past debt and deficit realizations, and by excluding these payments from fiscal accounts, primary balance reveals the current fiscal policies in a more straightforward way (Archibald & Greenidge, 2006, p. 7).

1.2.1 How Does Debt Evolve Over Time? A Law of Movement for Public Debt and Conditions for Solvency

In this part, to accomplish the above-mentioned objective, the debt dynamics are covered in a simple yet insightful formal model for a stylized closed economy whose only type of debt is in local currency. Those dynamics constitute the background for the fiscal reaction function. Therefore, their formal derivations are important for public debt sustainability considerations.

The first component of the public debt dynamics is the intertemporal budget constraint. The central intuition behind the budget constraint is that the existing debt stock of the country mirrors its past deficits incurred. In fact, the existing stock of debt is the summation of former stock of debt, current deficit and other flows. Since there is an interest payment associated with any debt, the debt accumulation continues unless the deficit is financed with other methods. If the deficit and interest payments are serviced with new borrowing, the country faces a vicious circle of debt and deficit (Domar, 1944, p. 799).

Formally, this vicious circle can be formulated through the notation listed below.

D_t	: Debt Stock	$D_t = D_{t-1} + \Delta D_t$
I_t	: Interest Expenditure	$I_t = i_t D_{t-1}$
R_t	: Government Revenues	
G_t	: Primary Spending	
PB_t	: Primary Balance	$PB_t = R_t - G_t$
i_t	: Nominal Interest Rate	
r_t	: Real Interest Rate (Fisher Equation)	$r_t = \left(\frac{1+i_t}{1+\pi_t}\right) - 1$
π_t	: Inflation	
P_tY_t	: Nominal GDP	$P_tY_t = (1+\pi_t)(1+g_t)P_{t-1}Y_{t-1}$
g_t	: Growth Rate	

Using the above notation, the vicious circle described by Domar (1944) can be formulated as follows:

$$G_t + iD_{t-1} - R_t + OT_t = (D_t - D_{t-1}) \qquad (1)$$

Equation (1) formally exhibits the public debt dynamics. From this equation, the nexus between budget constraint and the law of motion of debt dynamics can be extracted assuming that the debt is equal to the sum of the current debt accumulation or change in debt which is the right-hand side of the equation. Additionally, interest spending is the second component of the left-hand side of the equation, which is nothing but the interest rate times past debt. On the left, R_t represents the government revenues excluding interest earnings and G_t denotes government spending. The OT_t on the left-hand side refers to other flows of debt dynamics, including expenditures not included in G_t such as contingent liabilities and financing sources outside borrowing, including privatization and seigniorage. However, it is assumed that such flows are non-existent for the sake of simplicity for the time being.

Taking all these issues into account, Equation (1) may be rephrased as:

$$-PB_t + i_t D_{t-1} = (D_t - D_{t-1})$$

Solving for D_t;

$$D_t = (1 + i_t)D_{t-1} - PB_t \qquad (2)$$

Equation (2) is a simple and powerful illustration of how debt relates to past debt and primary balance. This equation states that public debt is the summation of the past debt, the interest paid on initial debt and the primary balance. It is an expression revealing the change in debt over time. In other words, it is a law of motion for debt dynamics. This expression is essentially a reorganized budget constraint for one period. Thus, it enables to calculate the level of debt, provided that the values on the right-hand side of the equation are known. Moreover, this equation explains what happens to the debt over time. It can also be defined as a reorganized budget constraint. It relates the debt in the period $t-1$ to the debt in period t. Manipulating this expression with some forward substitution, the intertemporal budget constraint and the solvency condition can be derived.

Iterating for the first two periods:

$$D_1 = (1+i)D_0 - PB_1$$
$$D_2 = (1+i)D_1 - PB_2$$

Plugging the first row in the second one;

$$D_2 = (1+i)((1+i)D_0 - PB_1) - PB_2$$
or
$$D_2 = (1+i)^2 D_0 - (1+i)PB_1 - PB_2$$

Following this sequence and repeating the iteration for each subsequent year, the intertemporal constraint for the terminal year N can be found as;

$$D_N = (1+i)^N D_0 - \sum_{j=1}^{N}(1+i)^{(N-j)}\, PB_j \qquad (3)$$

This expression relates the debt level at time N to debt level at the beginning , D_0, and the primary balances between periods 1 and N. Dividing each side of the Equation (3) by $(1+i)^N$ and solving for D_0;

$$D_0 = \sum_{j=1}^{N}\left(\frac{1}{1+i}\right)^j PB_j + \left(\frac{1}{1+i}\right)^N D_N \qquad (4)$$

Equation (4) simply illustrates how the initial debt is related to the terminal debt and the discounted value of primary balances. Here, the discount factor for primary balances and debt involves the number of years until they occur and the corresponding interest rate. However, in order to reach a more intuitive expression for the analysis, a restriction on the terminal debt is needed. Otherwise, any level of primary balance will be consistent with the above equation, and from a debt sustainability perspective, there would be no conclusion to draw.

The constraint to be imposed is the disallowance of the *Ponzi scheme,* which can basically be defined as financing the existing debt by issuing new debt in every round on a continuous basis. Obviously, such a scheme is not a solution to accumulated debt but only a temporary suspension, which is clearly not sustainable since it is literally impossible to find new investors every time new funds are needed. As the debt is effectively never paid back through primary balances, the new investors will be unwilling to finance the ever-increasing debt of the country with mounting risk of default. In the literature, this restriction is also called the *transversality condition*. This condition essentially implies the non-existence of a Ponzi scheme. By imposing the transversality condition, the Ponzi scheme is invalidated, forcing the government to deplete the existing debt in the terminal period by generating primary surpluses rather than relying solely on new investors. More formally, as time goes to infinity, the last term in Equation (4) needs to be equal to zero.

$$\lim_{N\to\infty}\left(\frac{1}{1+i}\right)^{N} D_N = 0 \qquad (5)$$

The restriction that Equation (5) imposes does not prevent the terminal debt from being positive and does not rule out increasing debt. Nevertheless, if the initial public debt is greater than zero, the economy has to run primary surpluses on a continuous basis to be solvent and should not rely on a Ponzi game for financing. In other words, the transversality condition prohibits the creation of excessive public debt without covering the initial debt and compounding the interest burden thereon (Burnside, 2005, p. 13). Thus, for the government to be solvent, the principal has to be serviced through the discounted primary surpluses occurring in the subsequent periods.

Hence, the solvency condition for the government reads:

$$D_0 = \sum_{j=1}^{\infty}\left(\frac{1}{1+i}\right)^{j} PB_j \qquad (6)$$

In the absence of the transversality condition on the intertemporal budget constraint, any array of primary balance would be consistent with the solvency condition. In other words, only after restricting the government by inhibiting the Ponzi game, an insightful solvency condition can be reached.

1.2.2 Key Conditions and Equations for Modelling Debt Sustainability: Augmenting the Formal Framework

The above-mentioned intertemporal solvency condition states that the sum of the initial debt and future stream of primary expenditures should amount to the present value of the future flow of revenues. According to this term, a government is solvent if it is able to repay its existing debt via future primary surpluses. However, this solvency condition depends on how future events will unfold. Countries with very high debt ratios might still be deemed sustainable provided that they rely solely on the governments' ability to generate a future stream of primary surpluses. The government might also opt to attract new investors whenever a new fund is needed for repayment (Ponzi Scheme). However, such a scheme gets riskier in every round and will eventually fail since it is impossible to bring new investors into the system forever.

Nevertheless, using these two terms, a simple but intuitive academic definition of public debt sustainability can be made. Formally, if the policymaker can satisfy the intertemporal solvency condition (i.e. No Ponzi Scheme), then we can infer that the public debt is sustainable from a narrow perspective. In this case, the expected future primary surpluses cover the existing accumulation of debt. It might be stated that this is a relatively soft requisite for sustainability since, according to this definition, governments with a high amount of deficit and debt burden may still be deemed sustainable. Also, intertemporal solvency largely depends on the uncertain future realizations of primary surpluses. It renders sustainability contingent on expectations about the potential course of upcoming events that might not occur in reality. In practice, the indicated higher primary balance might be achieved by a tax hike, a spending cut or by a combination of both. Another possibility is a money supply increase by the central bank to achieve an effective negative interest rate through higher inflation which is high enough to outweigh the nominal interest rate leading the actual value of the public debt to shrink (Jha, 2012, p. 21).

The proposition that the future stream of primary surpluses must match the current debt is also called a Ricardian Regime in the literature. In this case, future revenues are assumed to be equal to the existing public debt. However, in the non-Ricardian regimes, the government does not make a binding commitment to cover the current debt with the future flux of primary balances as a certain portion of the public debt will be covered by financial repression caused by money creation (Greiner & Fincke, 2015, pp. 2-6).

Nevertheless, such deliberate alterations in the debt level are not considered appropriate by many economists and the authorities. According to the IMF and the World Bank, for instance, *"Debt is sustainable if the country (or its government) does not, in the future, need to default or renegotiate or restructure its debt or make implausibly large policy adjustments"* (Hassine, 2015, p. 4). This approach states that the public debt is not sustainable if;

- A debt restructuring is required,
- The pace of accumulation of debt is swifter than the growth of the government's ability to repay (GDP)
- Some level of painful economic policy adjustments in the form of retrenchment will be needed in the future.

In modern economic understanding, however, what matters is not the level of debt but its position against the financial potential of the economy. Here, the capacity to repay is generally measured by some macroeconomic indicators such as GDP and this ratio is also called *"public leverage"*. In this sense, the debt scaled by the capacity to pay, i.e. *Debt/GDP ratio,* is a very useful and powerful tool used for public debt sustainability analysis. The path of debt/GDP ratio gives quite a hint about the sustainability of the public debt in the country. It is a very commonly used indicator of capacity to repay because, calculated by the value-added approach, it reflects the sum of all economic activities provided in the economy. Oftentimes, it proves to be a more useful measure for analysing the solvency position of the economy compared to the sole magnitude of the public debt. For this reason, despite its restricted capacity as an indicator, the debt/GDP ratio is prevalently used in the literature.

From this perspective, public debt is sustainable if the ratio of current debt level to capacity to pay is steady or declining and is not too high. If the ratio of existing debt to capacity to repay (GDP) is remaining high and/or increasing, then the debt is deemed unsustainable. Additionally, suppose the debt ratio is quite high initially. In that case, even a continuous decline in the ratio does not imply sustainability until the ratio reaches a certain level that is sufficiently low (Jha, 2012, p. 22). Thus, to add some more insight to the analysis, the debt/GDP ratio can be incorporated into the formal derivations to account for the above-mentioned economic dimensions brought by the level of public debt scaled by the capacity to pay.

The debt dynamics equation was,

$$D_t = (1 + i_t)D_{t-1} - PB_t \quad (2)$$

Following the above-mentioned definition of the evolution of debt, this expression can be scaled by GDP using the notation P_tY_t.

$$\underbrace{\frac{D_t}{P_tY_t}}_{d_t} = \frac{(1+i_t)}{(1+\pi_t)(1+g_t)} \underbrace{\frac{D_{t-1}}{P_{t-1}Y_{t-1}}}_{d_{t-1}} - \underbrace{\frac{PB_t}{P_tY_t}}_{pb_t}$$

where $P_tY_t = (1+\pi_t)(1+g_t)P_{t-1}Y_{t-1}$

Incorporating the Fisher equation;

$$r_t = \left(\frac{1+i_t}{1+\pi_t}\right) - 1$$

the scaled debt dynamics equation above can be simplified as:

$$d_t = \frac{(1+r_t)}{(1+g_t)} d_{t-1} - pb_t \qquad (7)$$

The influential factors on debt dynamics can be analysed from different angles using this equation. A higher primary balance, for instance, lead to a lower d_t. A higher initial debt, on the other hand, might give rise to a higher d_t. On the contrary, a higher growth rate brings about a lower d_t as it improves the capacity to pay. Finally, a higher real interest rate results in higher d_t by increasing the interest expenditure payments.

According to Bohn (1998), this equation is quite significant for the stationarity of the debt series. It makes it harder for the formal tests to determine the (non)existence of a unit root. For instance, if r_t= 0.02 and $g_t = 0.04$, then, $\frac{(1+r_t)}{(1+g_t)}$ will be 0.98, which is very close to unity but still stationary. Hence, the debt dynamics equation involving r_t and g_t generates a challenge for the formal stationarity tests to produce precise results in distinguishing the sustainable debt from unsustainable ones (Burger et al., 2012, p.8).

Using an abbreviation for the term $\frac{(1+r_t)}{(1+g_t)}$ in Equation (7) and denoting the whole term as ϕ_t, the budget constraint or debt dynamics can be rewritten as follows:

$$d_t = \phi_t d_{t-1} - pb_t \qquad (8)$$

It simply denotes the current level debt/GDP as a function of its lagged values and the current primary balance scaled by the capacity to pay.

Equation (8) can also be illustrated in a phase diagram to clarify debt dynamics. On the phase diagrams below, the vertical axis depicts the debt in the current period, whereas the horizontal axis shows the debt level of the previous period. For simplicity, it is assumed that there is a linear relationship between d_t and d_{t-1} in that pb and ϕ are constant. The value of ϕ determines the explosiveness of the debt in the economy. If $\phi < 1$, as illustrated in Figure 1 below, the initial level of debt, d_0, converges to d^* where d_t and d_{t-1} are equal and remain at this equilibrium level thereafter. The d^* is the sustainable level under the primary balance level pb_t.

Nevertheless, in the explosive debt case below (Figure 2), the real interest rate is higher than the growth rate ($r > g$), and therefore for any positive level of $d_0 > d^*$ the debt/GDP ratio deviates from sustainable level unboundedly, and the speed of growth can be unexpectedly high.

Differencing Equation (8) reveals more insights about debt dynamics.

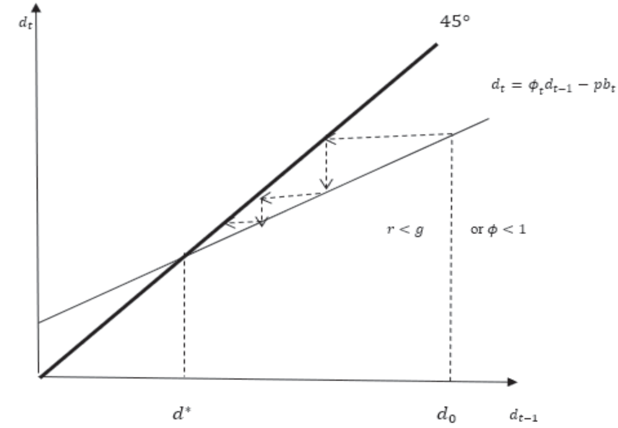
$d_t = \phi_t d_{t-1} - pb_t$ (8)

Subtracting the previous period debt d_{t-1} from both sides;

$$d_t - d_{t-1} = \left[\frac{1+r_t}{1+g_t} - 1\right] d_{t-1} - pb_t \quad \text{or,}$$
$$\Delta d_t = (\phi_t - 1) d_{t-1} - pb_t \qquad (9)$$

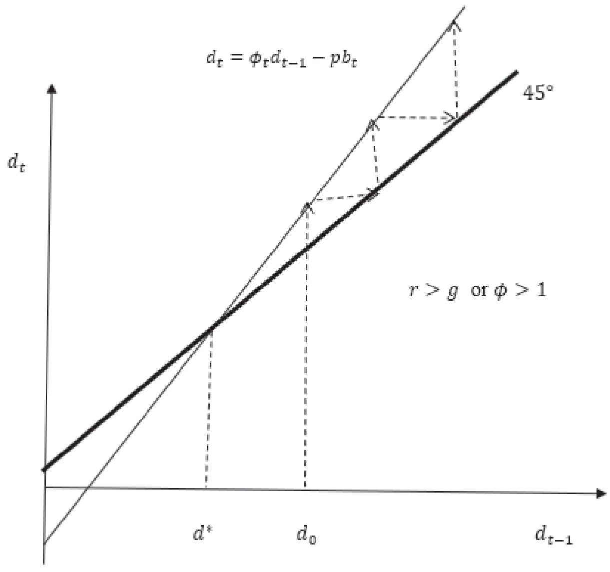
The momentum of debt and the governments' effort for stabilisation can be observed from Equation (9). The term in the brackets simply indicates the proportion of the debt accumulation arising due to interest reimbursements of the former period. The equation simply states that if the real growth rate is smaller than the real interest rate, then the debt is deemed explosive. In that case, the public debt automatically rises even in the absence of new borrowing. When this happens, high levels of primary surpluses (fiscal reactions) are needed for offsetting the explosiveness in debt dynamics. Hence, the magnitude of pb_t the ratio is a good indicator for detecting governments' ability to trim explosiveness in debt dynamics.

Figure 1 Stable Debt



Source: IMF Institute for Capacity Development Training Material

Figure 2 Explosive Debt



Source: IMF Institute for Capacity Development. Training Material

Equation (9) can also be used for calculating the level of pb_t required to stabilize the d_t by setting $\Delta d_t = 0$. Such a restriction transforms Equation (9) into;

$$pb_t = (\phi_t - 1)d_{t-1}.$$

Hence, the primary balance requirements for debt stabilization can be calculated by plugging in the corresponding values on the right-hand side of this equation. However, the calculated level of debt stabilizing primary balance hinges on numerous factors, which can be summarized as follows:

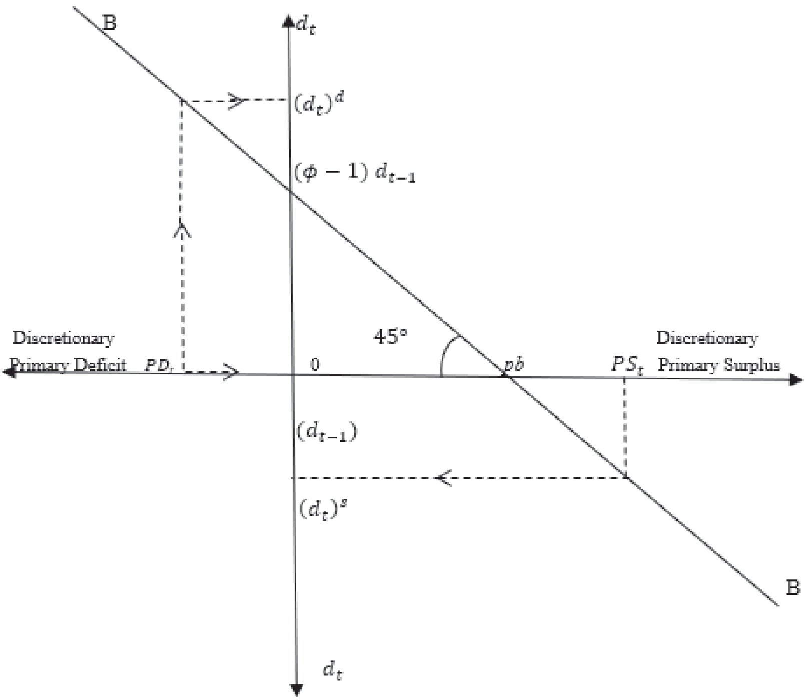
- The first determinant of the required primary balance is the amount of public debt itself. If the current extent of the debt/GDP ratio is quite high, then seemingly large levels of primary surpluses are needed for reducing the current level of debt ratio and also for hindering it from increasing even further.
- Secondly, if the differential between the actual growth rate and the interest rate is great, then the debt stabilizing primary balance will also be high.
- Finally, the third factor is the availability of other sources of financing such as privatisation or seigniorage. Alternative financing options reduce the primary balance requirements for debt stabilisation. Also, it should be noted that if the government aims at reducing the debt instead of preserving the existing level, then the generated primary surpluses should exceed the debt stabilising level.

At this point, a graphical illustration of the bond between debt and primary balance can illuminate the point more effectively. In the figure below, unlike phase diagrams above, the horizontal axis depicts the possible levels of pb_t. The right-hand side of the axis represents a primary surplus, and the left-hand side shows the primary deficit. The vertical axis is devoted to d_t. Above the horizontal axis, it rises, and below the horizontal axis, it falls. At the origin, $pb_t = 0$, and the debt level is d_{t-1}.

The BB line is the graphical representation of $d_t = \phi_t d_{t-1} - pb_t$. This line relates the primary balance at the period t to the changes in d_t. Since the value of d_t on the intersection point is d_{t-1}, the distance between any point on the vertical axis and the origin will be Δd_t. The slope of the BB line is obviously negative and has a value of -1. This line intersects with the vertical axis above the origin if the interest rate is higher than the economy's growth rate. In contrast, if the interest rate is lower than the growth rate, the intersection will occur below the origin.

The figure below illustrates the first case where the interest rate exceeds the growth rate. Under this scenario, a primary deficit such as PD_t which is different from pb_t raises the debt level from $(\phi - 1)\ d_{t-1}$ to $(d_t)^d$, while a primary surplus exceeding pb_t will lower the debt/GDP ratio to $(d_t)^s$. The opposing case, which is not illustrated on the diagram, occurs when the BB line intersects with the vertical axis below the horizontal axis and $(\phi - 1)\ d_{t-1}$ is smaller than zero. Under this scenario, the government is able to run a primary deficit up to the intersection point of the BB line and the deficit sector of the primary balance axis (Makin, 2005, s. 288).

Figure 3 Debt/GDP Ratio and Primary Balance



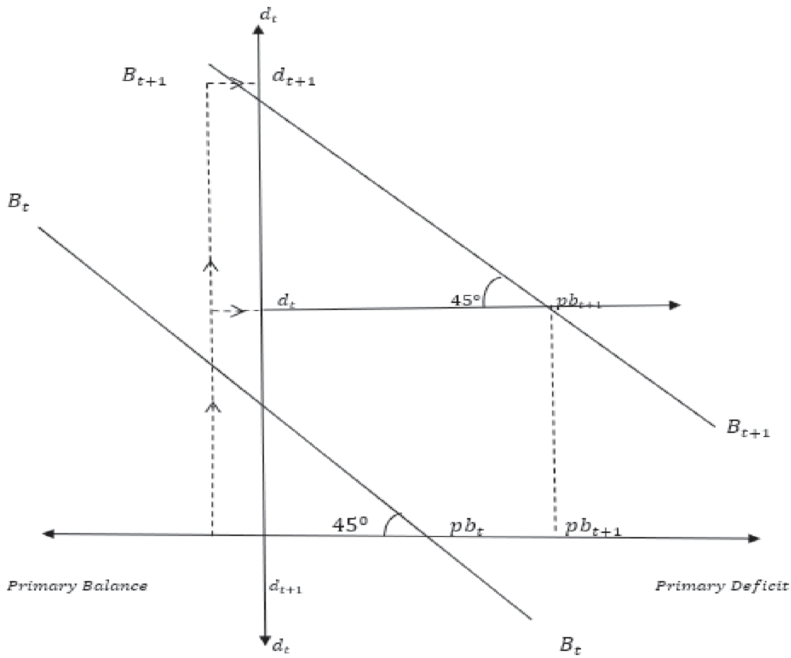
Source: Makin, 2005

Along with the above analysis, the vicious circle between debt, primary balance and interest rate can also be illustrated with an augmented version of Figure 3.

Figure 4 below illustrates such a scenario. A primary deficit at the level pb_t in the period t increases the debt level to d_t . Such a shift in debt makes the investors more concerned about the soundness of the public sector stance and the likelihood of an insolvency or default. These heightened concerns among the investors bring about a higher risk premium and consequently a higher interest rate in the next period.

The higher interest rate in the period $(t + 1)$ leads to lower investments and, thereby, lower growth and increased interest bills paid on the government debt. These two channels worsen the public finances. Thus, the $B_{t+1}B_{t+1}$ line in the figure above has a larger intersection value than the B_tB_t line. This implies that a higher primary surplus, say, pb_t, is needed for offsetting the difference and stabilise the public debt. The debt dynamics, in this case, are unstable, and as the fiscal deficit prevails in all subsequent periods, the financial crisis is unavoidable in the following periods (Makin, 2005, p. 289).

Figure 4 Perpetual Primary Deficit and Unsteady Debt



Source: Makin, 2005

The counter inference from this line of reasoning is that if the government reaches an adequately large primary surplus in period t, then, vicious circle operates in the opposite direction and the country ends up in a position with a lower interest rate, higher investment, higher growth, reduced fragility and declining d_t (Makin, 2005, p. 289).

According to Makin (2005), the distinction between the two debt trajectories can be determined by means of Equation (9) above. This equation can also be written as follows;

$$d_t - d_{t-1} = \left[\frac{r_t - g_t}{1 + g_t}\right] d_{t-1} - pb_t \qquad (10)$$

The right-hand side of the equation is composed of an automatic debt path and primary balance. The first term on the right-hand side indicates how the debt will evolve in time depending on the interest rate and growth rate alone when the primary balance is zero. The second term on the right is the familiar primary balance. According to Makin (2005), the denominator $(1 + g_t)$ can be omitted for simplicity.

The distinctive feature of this equation is that it reflects the efforts of the government to offset the outcome occurring as a consequence of the first term on the right-hand side. This outcome can be favourable or unfavourable depending on the levels of growth and interest rate. The government can react to the outcome by using the primary balance as a tool. It can be simply pointed out that the outcome will be favourable, provided that the real interest rate is less than the growth rate. In this case, the product of $r_t - g_t$ and d_{t-1} will have a negative sign as most of the time, the debt stock is greater than zero. The unfavourable case occurs when the opposite happens, i.e. when the growth rate is less than the real interest rate. Assuming a positive initial debt again, the automatic part of the equation will have a positive sign.

An important caveat worth noting at this point is that if the outcome is favourable, it does not necessarily imply that the debt will fall or vice versa. Whether or not the debt will fall next term is down to the government's reaction via primary balance. If the primary deficit is high enough, the debt might increase even if a favourable outcome from the automatic dynamics occurs. The favourable outcomes only refer to stability in the debt path. In other words, in the case of a favourable outcome, once the debt is forced to move off the equilibrium, it will eventually return to equilibrium. On the other hand, if there is an unfavourable situation, the debt will be unlikely to return to equilibrium once it is forced to leave it.

It can be noted from these figures that if the slope of the dynamics curve is less than one, $\phi < 1$, then the debt level returns to equilibrium, or in other words, equilibrium is stable. On the contrary, if the $\phi > 1$, the debt is deemed explosive and moves off the equilibrium thereafter. The reason is that the economic growth in the economy outpaces the real interest rate. The equilibrium occurs at the intersection of the two lines because, on the 45-degree line, debt is always stable with $d_t = d_{t-1}$. To the right of this point, $d_t < d_{t-1}$. Under the $\phi > 1$ scenario, the economy is not growing sufficiently fast to offset the real cost of extra borrowing. The same level of initial debt will this time lead to an explosive debt pattern, and this is when the fiscal reaction of the government comes into play.

It is essentially clear that for stability, the change in the debt level needs to be zero or $\Delta d_t = 0$. Also, from Equation (10) above, it is clear that in order to reach this type of stability, the automatic component of the debt path needs to be equal to the debt stabilising primary balance. Put differently, the debt level is stable if the government is capable of making an equivalent response to the automatic debt dynamics.

Bearing this point in mind, the debt stabilising primary balance can be calculated by setting $\Delta d_t = 0$.

$$pb^* = \frac{r_t - g_t}{1 + g_t} d_{t-1} \qquad (11)$$

According to this equation, the debt stabilising primary balance is equal to automatic debt dynamics times the previous debt level. Obviously, if the previous level of debt, d_{t-1} is high and negative, then the primary balance of the next period needs to be in surplus by the same amount. Additionally, it is positively correlated with the difference between the interest rate and growth rate. This point indicates that the capacity to pay and the speed of increase in the costs of debt must grow equally for the debt to be stable.

The debt stabilising primary balance level is also proportional to the initial level of debt, d_{t-1}. It is clear that the higher the initial debt, the harder it is to stabilise the debt ratio both politically and economically. It requires numerous fiscal adjustments and measures essential for attaining the indicated high level of debt stabilising primary balance. If the government fails to reach this level, the debt will continue rising, and consequently, it will gain momentum and keep growing ever after. The permanently increasing debt will lead to a more severe vulnerability in the economy, which is a highly hazardous situation for the country. The most appropriate way to revert this procedure is to run a positive fiscal reaction by means of primary surpluses. Hence, how the government reacts to the debt level is crucial for fiscal sustainability.

1.2.3 A General Form Fiscal Reaction Function

Monitoring the government's ability to generate prolonged primary surpluses is also crucial, especially in an environment full of uncertainties. At this point, the fiscal reaction function proposed by Henning Bohn (1998) proves to be a valuable tool by at least partially embodying such an abstract concept and reducing the perplexity. Simply put, the fiscal reaction function facilitates the debt sustainability analysis operationally to make concrete reasoning about the debt sustainability standards of the country.

To understand how Bohn (1998) managed to formulate debt sustainability operationally, we need to go back to debt dynamics.

The solvency condition was:

$$D_0 = \sum_{j=1}^{\infty} \left(\frac{1}{1+i}\right)^j PB_j \qquad (6)$$

For this condition to hold, the amount of accumulated fiscal liabilities needs to be smaller than the discounted value of the primary surpluses. This simple condition effectively constrains future fiscal policies, and operational formalization of debt sustainability should incorporate this restriction into the analysis. However, the above-mentioned definitions of solvency based on the stock of budgetary liabilities and primary surpluses are far beyond being effectively operational. The reason is that there are several ways of meeting solvency condition, and not all of them are good for the government. Fiscal solvency is a sole arithmetic equation, and there are numerous ways of fulfilling the same intertemporal conditions.

The solvency condition implies that the accumulated debt needs to be matched by a future stream of primary surpluses. Algebraically, this condition has to hold for solvency ex-post, but the equation, per se, does not indicate which side of the equation must be tuned to maintain the solvency condition. In this respect, the solvency condition does not restrain the government from altering both sides of the equation. The government can indeed directly modify the debt level using its economic and political sovereignty.

The right-hand side of the equation is the part that has been discussed so far from the fiscal policy perspective. However, the governments can redefine their debt obligations (the left-hand side of the equation) with their sovereign power. This can happen in the form of restructuring or deliberate inflation to lessen the real value of the outstanding debt, namely financial repression. By means of such instruments, the sovereign can alter the equation's left-hand side and be solvent without needing to raise primary surpluses (Burnside, 2005).

However, those measures can be considered an additional tax on the creditors, which is an extra burden for the economic agents. Besides, they will undercut the sovereign's overall credibility and thereby have economic consequences, especially in the form of a limited future stream of credits, which eventually leads to higher borrowing costs on the economy and weaker financial health overall. Contrastingly, playing with the right-hand side of the equation and committing itself to raise primary surplus persistently is a more credible way of guaranteeing solvency. The second type of measures needs to be backed by solid fiscal policies and obviously are harder to implement, but the outcome turns out to be more positive and desirable.

In other words, there are good or bad ways of achieving fiscal solvency, and this dichotomy has significant implications on the definition of sustainability from an operational perspective. As the "bad" forms of reaching fiscal solvency have undesirable ultimate outcomes, public debt can be deemed sustainable only if it is achieved by implementing "good" ways of fiscal solvency measures. From this argument, it is pretty clear that preserving debt sustainability is more challenging than maintaining solvency. Put differently, the solvency condition per se is quite soft a constraint from a fiscal policy perspective. The debt sustainability analysis is also based on the governments' commitment to implementing only the "good" ways to maintain fiscal solvency (Chalk & Hemming, 2000).

This connection between solvency and sustainability is inherently forward-looking and entails an in-depth analysis of fiscal tools and the fiscal authorities' potential future behaviour. The unknown course of future fiscal developments in the country could bring about several pleasant or unpleasant outcomes depending on the policy choices of the sovereign. The government could commit itself, today, to run adequate primary surpluses and stay on the "good" side of the equation, but whether it can transform this choice into a binding commitment boils down to a combination of its real efforts and the external conditions which are uncertain and challenging to predict (Greiner & Fincke, 2015).

Sustainabilitywise, there is always uncertainty incorporated into the picture as solvency does not always imply sustainability. Bohn (1998) claims that the stationarity of the data is essential for sustainability, but it is tough to reject the unit root for debt/GDP series. According to him, because of that difficulty, even if the debt/GDP starts falling towards its mean, the real underlying force behind the decreasing debt cannot be discovered by relying solely on the unit root tests. It might be associated with the fiscal policy design or a random occurrence of a favourable event. Hence, there is a significant amount of uncertainty surrounding the debt sustainability analysis. Thus, to reduce subjectivity and improve the concreteness of the debt sustainability analysis, the government's fiscal behaviour should be modelled to find out if the government is employing the "good" ways of achieving fiscal solvency. Bohn (1998) points out that, by means of fiscal reaction functions, the aforementioned uncertainty can be overcome since the function properly tests if a, say, decline in debt is occurring as an outcome of fiscal policy actions of the government or not. In other words, the fiscal reaction function generates direct evidence about the systematic fiscal counteractions of the government to debt fluctuations (Bohn, 1998).

Another elegant feature of this model, fiscal reaction function, is that it liberates the analysis from being a sole subjective analysis and allows the researcher to pursue the analysis more positively. In other words, by using this model, a subjective outline of the best fiscal policies and responses by the government are not needed for fiscal behaviour optimization. Instead, the link between debt dynamics and fiscal behaviour can be analytically tested through fiscal reaction function. In this sense, the model can be thought of as a combination of an average form of fiscal policies that are basically the sovereign's fiscal responses to economic circumstances and indicators such as debt, growth, etc. Put differently, rather than identifying the "best" fiscal policies to achieve economic and social outcomes, the fiscal reaction function attempts to shed light on the actual mechanisms of fiscal policies (Debrun, 2015).

However, in this respect, the fiscal reaction function should not be confused with fiscal rule. While the fiscal reaction function positively exhibits how the fiscal policy might behave, the fiscal rules are only stringent constraints on the fiscal policies. The fiscal rules can only be thought of as estimated fiscal reaction functions (Plödt & Reicher, 2014).

Formally, in its most general form, the fiscal reaction function can be formulated as follows:

$$pb_t = F(d_{t-1}, X_t) + \varepsilon_t \qquad (12)$$

The fundamental variable used to outline the fiscal behaviour in the model is, without doubt, the primary balance. The reason is twofold:

- It is the main determinant of the solvency condition in Equation (6) above. Therefore, it is strictly connected to the very notion of sustainability. As we mentioned earlier, solvency is a prerequisite for sustainability.
- It does not fluctuate due to interest payments since interest payments are the consequences of past policies that are no longer controllable. In other words, the primary balance eliminates the interest reimbursements on the existing debt and responds systematically to the debt level of the previous periods and the output gap procyclically or counter-cyclically. These responses are vital from an operational perspective.

This function's primary concern is the role of fiscal reactions on public debt stabilisation through fiscal adjustments. Fiscal adjustment, particularly refers to the gradual transformation of the fiscal stance to a more sustainable and sturdy condition. As noted, there are "good ways" and "bad ways" of fiscal adjustments to achieve solvency. However, it must also be noted that several "good" ways of running fiscal policies, and each of them has an entirely different impact on the economy. The sovereign can raise primary surpluses through various adjustments, including taxes or lowering expenditures. The composition of the involved policies is also crucial for the quality of implemented policies' eventual outcome. Any change in the involved factors, such as the initial level and composition of the public debt, and the composition of fiscal policies used, take part in the continuum and the performance of the fiscal adjustments.

Undoubtedly, the primary explanatory variable of a typical fiscal reaction function is the previous period debt level. The magnitude of the reciprocation to the previous period's debt level is an important means to specify the government's fiscal behaviour. The solvency condition implies that the discounted future primary surpluses should eventually match any expansion in the public debt. Besides, the transversality condition restrains the government from postponing the primary balance generation forever. Hence, the expected sign of the coefficient of the previous period debt in the fiscal reaction function model will be positive. The reason is based on the argument that the debt needs to be covered by primary balance improvements to avoid a Ponzi game.

The argument can also be illustrated over the formulation in Equation (12) above. The dependent variable, the primary balance, reacts to various control variables, which are denoted by X_t including the output gap. Those are the variables that stimulate the fiscal policy behaviour of the country. Finally, the last term on the left-hand side is obviously the error term for precision. However, to obtain a fiscal reaction function suitable for estimation, some derivations on the debt dynamics equation are needed.

Iterating Equation (7) for one period reveals;

$$d_{t+1} = \left[\frac{1+r_{t+1}}{1+g_{t+1}}\right] d_t - pb_{t+1} \qquad (13)$$

Equation (7) shows the main aspects of debt dynamics, and the equation above expresses the same dynamics in period t+1. The interest rate in this equation refers to the speed of automatic growth of debt when the primary balance is zero. However, the growth rate in the denominator is a kind of opposing force against the rise caused by the interest rate increase. A combination of these two forces determines the ultimate dynamics of the debt path. The last component on the right-hand side of the equation is obviously the primary balance, and the same equation can be rephrased in the form of a differential equation as follows;

$$\Delta d_{t+1} = \left(\frac{r_{t+1} - g_{t+1}}{1+g_{t+1}}\right) d_t - F(d_t, X_{t+1}) \qquad (14)$$

Equation (14) relates the debt differential to its current level. The term in the brackets describes the opposing forces which propel the debt dynamics. The Equation implies that if the interest rate is greater than the growth rate and the interest payments are financed with new borrowing (Ponzi scheme, $pb_t = 0$), then the d will grow automatically. The automatic manner of debt accumulation is also called the *"snowball effect"* (Debrun, 2015, p. 4).

In most countries and most of the time, r is greater than *g*. Therefore, mostly, to keep the $\Delta d_{t+1} = 0$, the government needs to run primary surpluses for stabilising the public debt. If the debt grows faster than the economy, the government would continuously increase taxes and cut spending to compensate in the medium and long run. Also, if r is greater than *g*, the debt will grow continuously, and in each row, a fraction of the existing debt will be added to debt stock, and consequently, the debt will grow exponentially. Therefore, the analogy of a snowball is quite insightful (Jha, 2012, p. 24).

However, for developing countries like Turkey, there can be long sequences of periods when the r is negative and/or effectively smaller than g. Therefore, at least theoretically, such countries do not need to run primary surpluses and also, r *will* exceed g eventually anyways. In such a case, ceteris paribus, the debt will come to an equilibrium below the current level, and the government revenues will grow at higher speeds compared to the public debt. Hence, the steady-state value of the debt will be smaller (Ferrarini & Ramayandi, 2012, p. 61).

As long as $\Delta d_{t+1} > 0$, the primary balance will continue to improve until it reaches an adequate level for stabilizing the debt. The stabilization of the debt materializes when the primary balance is large enough to overcome the opposing force of the "*snowball effect*". Therefore, the reactivity of the primary balance to debt dynamics is utterly important. What matters, in fact, is not the level of the primary balance at a certain point in time but the response it generates against the variations in the debt level. A positive reaction through primary surpluses to past debt is crucial for preserving solvency.

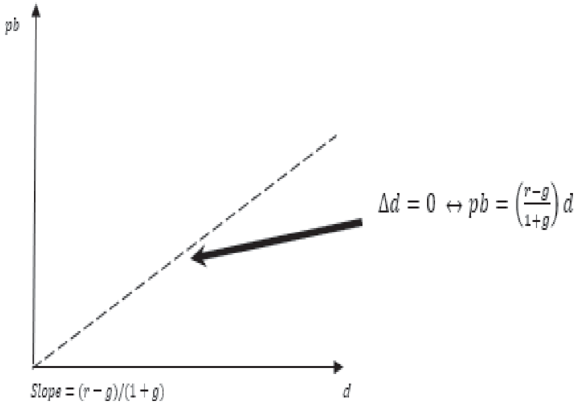
Bohn (1998) states that a small but positive fiscal response to the debt differential is sufficient for solvency. However, he agrees that the solvency is too narrow a notion about fiscal behaviour and debt sustainability is a much broader concept. Nevertheless, at this point, it is clear why the fiscal reaction function can be used as a powerful tool to emphasize public debt sustainability. A diagrammatic illustration can be used to discern this relationship.

The snowball effect and how it automatically accumulates debt via interest payments are depicted in the diagrams below. Also, the fiscal reaction function and how it measures the responses of fiscal behaviour to the debt dynamics are shown in the same figure as well.[1]

On the horizontal axis, the debt/GDP ratio is located, and the primary balance scaled by GDP is on the vertical axis. The dotted line demarcates the stable and unstable zones of fiscal dynamics. The assumption here is that there is a snowball effect where $r > g$.

[1] The following four diagrams are decomposed and reduced forms of the diagram in Debrun (2015) for the sake of simplicity and comprehensiveness.

Figure 5 Demarcation of Stable and Unstable Fiscal Behaviours



Source: Debrun, 2015

As it is clear from former discussions so far, the snowball effect is depicted formally by $\Delta d = 0 \leftrightarrow pb = \left(\frac{r-g}{1+g}\right) d$, which appears on the diagram as well. This formulation reveals *the debt stabilising primary balance,* which is not surprisingly a product of the snowball effect (Debrun, 2015, p. 5).

Through the demarcating line, debt is stable since $\Delta d = 0$. The primary balance is keeping the debt stable over this line. In the upper zone of the demarcation line, the primary balance is sufficiently larger than its debt stabilising level. As a result, the debt/GDP ratio falls systematically. In other words, the area above the line is consistent with the debt reduction, and the field below the line represents the pairs of debt and primary balance levels, which are in consistency with the rising debt/GDP ratio.

The reason becomes apparent when we reverse the argument. The primary balance is continuously below the debt stabilising level, which is not appropriate for covering the distortionary snowball effect. In this case, however, the size of the r and g matters, unlike the stable case. Consequently, the size of the zone will be determined by the magnitudes of these variables as well. As the interest rate rises, the line becomes steeper, and the area below it becomes larger, which increases the likelihood of an unsustainable debt. However, the point here is to explore how the fiscal reaction function fits into the picture.

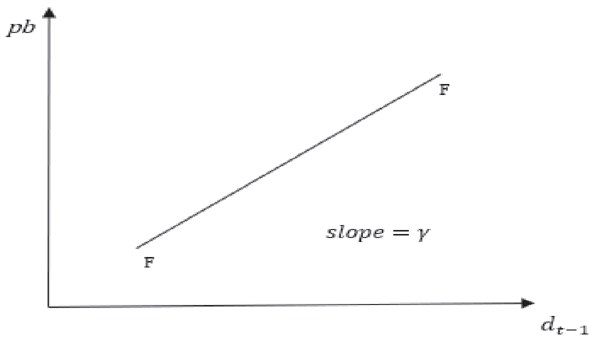
As noted, the average fiscal behaviour can be expressed by the following equation;

$$pb_t = \alpha + \beta X_t + \gamma d_{t-1} + \varepsilon_t \quad (15)$$

For simplicity, a linear fiscal reaction function is assumed. As indicated earlier, the expected sign of the lagged values of the debt variable is positive for ensuring solvency. This linear function can be illustrated in the figure above. The positive value of γ indicates a positive slope as well. The economic meaning of a positive γ is relatively straightforward. If the debt rises in the previous period, the government should reciprocate with an increased primary surplus. However, the numerical value of the γ is also quite crucial for the analysis. The higher the value of γ, the more sensitively the government reacts to a surging debt/GDP. On the contrary, if the value is low, the government is reluctant to respond to the mounting debt level.

An equilibrium can be reached and analytically tested for its stability by using the diagrams above. Stable equilibria refer to the cases characterized by stable or falling debt/GDP ratios, whereas the unstable ones are consistent with surging and explosive debt levels.

Figure 6 Fiscal Reaction Function

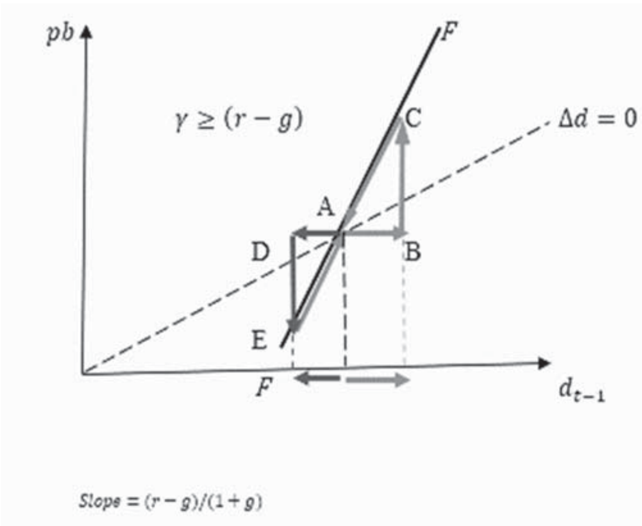


Source: Debrun (2015)

Figure 7 below is a combination of Figures 5 and 6 with some additional illustrations regarding the stability of the equilibria. In the previous section, we employed similar diagrams for stability analysis. However, this diagram differs from Figures 1 and 2 with the variables assigned to axes. In the figure below, the d_t and pb_t have just swapped their axes.

It is clear that stable equilibrium always returns to its original position when exposed to an external shock. Along the dotted line, the debt is stable, and therefore an equilibrium on this line will essentially be stable and reverting. In the figure below, the FF line again represents the fiscal reaction of the government, and since these two lines differ in terms of their slopes, they intersect. The critical point to observe in this diagram is that the FF line is steeper than the dotted demarcation line. This difference essentially guarantees the stability of the equilibrium, which is the geometric interpretation of the equilibrium. From the theoretical perspective, the stability of the equilibrium requires strong reciprocation by the government to the debt dynamics. The grey arrows illustrate a positive shock to the debt/GDP ratio, such as an instant need for financial resources or a bank recapitulation. In this case, the country moves from point A to B. As a steep fiscal reaction line is assumed, the government responds to this situation by raising the primary surplus, bringing it to point C.

Figure 7 Equilibrium and Stability



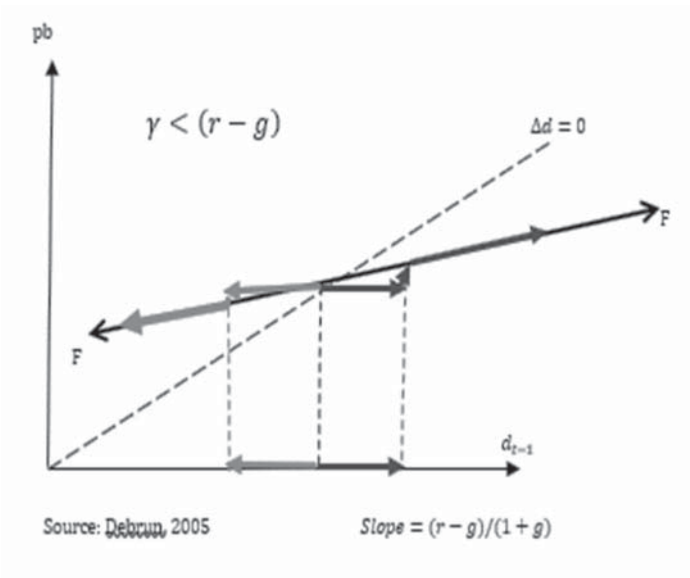
Source: Debrun, 2015

It is worth noting that point C is above the line, which demarcates stable and unstable zones. Above this line, the debt/GDP ratio falls. The reason is simply the amount of primary surplus raised, which outweighs the primary surplus needed to stabilise the debt. This differential brings the country from point C back to point A, where initial equilibrium was established.

The inverse argument applies when the government is exposed to a negative shock to debt, such as privatization, which pushes the country to point D on the diagram. In this case, the debt will fall due to an external shock, making the government more reluctant to run primary surpluses. This reluctance of the government will lead to a lower primary balance and force the country to move to point E, which is also on the line like point C of the previous case. This time, as the primary balance falls behind the debt stabilising level, the debt will keep rising. The result will be the same as the previous case, and once again, a stable equilibrium will occur (Debrun, 2015, p. 7).

On the other hand, unstable equilibria occur when the assumption about the slope of the fiscal reaction line is lifted. Suppose it becomes flatter than the demarcation line. In that case, the equilibria might be unstable because the government is no longer capable of responding to the surging debt level. In short, the scale of responsiveness, fiscal reactivity and sensitivity of the government is more significant than the level of public debt itself as far as the debt stabilisation is concerned.

Figure 8 Equilibrium and Instability



On the contrary, the diagram above illustrates the case where the fiscal reaction line is flatter than the demarcation line. In this case, the equilibrium will be unstable. Assume that a positive shock hits the debt level forcing the debt to move off the equilibrium. In this case, the economy will follow the black path. The shock will bring it first to a point below the fiscal reaction line, and then the government will raise the primary balance to some extent, but unlike the previous case, it will not suffice to stabilize the debt. In this scenario, the government's response will be too shallow to return the debt to its original position. In other words, the magnitude of the snowball effect is greater than the amount of increase in the primary balance. Consequently, the debt will start rising ever after, which is called “explosive debt”.

Similarly, when a negative shock hits the debt/GDP ratio, the economy moves away from equilibrium, and debt falls. As a response, the government reduces the primary balance. However, in this case, the economy is above the stable line, bringing about an ever-decreasing debt. Therefore, the primary balance will always be higher than the debt stabilising level. As a result, the debt will start declining permanently, which is called “implosive debt”.

The important takeaway from the figures above is that, in the case of an unstable equilibrium where the reaction of the government to the debt differential is shallow (i.e., flatter fiscal reaction line), the debt turns out to be explosive or implosive depending on the impact of the first shock hitting the debt ratio. In this case, no debt level will be consistent with debt sustainability. The level of debt that corresponds to the two lines' intersection point is the threshold debt level. Above this threshold, the debt is explosive and unsustainable, and below this level, debt is implosive and ever falling. Hence, to reach a mean-reverting equilibrium, a strong fiscal reaction in the form of primary balance improvements as a retaliation to a surge in debt level is needed. If this happens, then public debt sustainability is guaranteed. Otherwise, when the strength of response to debt movements is low, there will be a debt limit above which the debt will be unsustainable.

The strength of the response can be measured by comparing the snowball effect and the value of γ. In other words, the marginal increase in the primary balance needs to be higher than the real interest rate growth differential, $r - g$. More importantly, even though a shallow response is adequate for fiscal solvency, according to Bohn (1998), it does not prevent the explosive debt from showing up, which is unsustainable from the debt stability perspective.

The likelihood of an explosive debt is quite an important indicator for the government when designing their alternative strategies. Just like any other economic variable, there is also uncertainty associated with this parameter to some extent. The uncertain conditions in the economy shape the fiscal behaviour and parameters that drive the equilibrium movements.

The components of the snowball effect, r and g are intrinsically uncertain as their future levels cannot be known with precision. This uncertainty directly affects the slope of the demarcation line above. As a result, the location of the equilibrium will vary depending on the uncertain future values of r and g. Consequently, the slope of the line becomes a random variable, and any value of the slope gives rise to a different equilibrium. The equilibrium level of debt to which the debt level will converge is also not certain due to the randomness of parameters. In other words, there is no unique and certain level of debt but a distribution thereof.

Additionally, the magnitude of the fiscal responsiveness is also uncertain. It cannot be precisely predicted how the government will retaliate to the debt dynamics. In other words, geometrically, the slope of the fiscal reaction line is also a variable (Jha, 2012, p. 28). The degree to which the government will be committed to stabilizing the debt by using the primary balance as a tool is mostly unpredictable. This degree is significant for the existence of debt sustainability. Therefore, the uncertainty about such an important indicator leads to uncertainty about the equilibrium level of debt as well.

Also, depending on the steepness of the fiscal reaction curve, the equilibrium may be stable or not. For the same reason, it can correspond to a high or a noticeably low level of debt and, a priori, where the debt realization will occur may not be known. The country might end up with very low but unsustainable debt, or conversely, with a very high but sustainable debt equilibrium. Moreover, the fiscal behaviour of the government and perceptions of the other economic agents might change in time, causing a shift between equilibria in the economy. For instance, due to an external shock, the economy might move from a stable and good equilibrium to an unstable one.

However, there is an upper limit to the primary balance beyond which the government is no longer capable of using the primary balance as a tool. This situation is called *"adjustment fatigue"*. In this case, the prolonged rises in debt lead to a fall in primary balance (Ghosh, et al., 2013, p.3). Furthermore, the differential between the existing public debt and this threshold limit is called *"fiscal space"* (Debrun, 2015, p. 2). It measures the fiscal manoeuvrability of the government after accounting for public debt concerns. Higher fiscal space enables the government to make higher spending on public welfare such as infrastructure and transfers. Clearly, a highly indebted country will be forced to prefer to invest less in the country's overall welfare. In contrast, a country with a low amount of debt (i.e. higher fiscal space) will be able to make larger investments. Moreover, if the fiscal space is vast, there will be less need to incur distortionary costs of debt reduction. Therefore, debt reduction via primary surplus can be delayed until a favourable growth environment is reached in case of an ample fiscal space (Ostry, et al., 2015, p.3).

1.2.4 Potential Economic Consequences of Fiscal Reactions

In medicine, every treatment has its side effects. By analogy, the fiscal reaction strategies might also have adverse effects on the economy while remedying the public debt problems as well. There are two main types of fiscal reaction choices available to the government when responding to increasing debt to bring it back to stable levels. One of those strategies involves an upfront rise in the primary balance, which occurs early in the course, whereas the other option is to conduct a response with a delay and with some level of adjustment. The former is also called *front-loading,* while the latter is also known as *back-loading* (Baldacci et al., 2004, p.4). Front-loading refers to the situation where the government applies policies to reach the targeted level of primary balance as soon as possible. On the contrary, back-loading allows the government to implement gradual policy changes toward their stabilisation goals.

The former type of policies is employed mainly when the government faces harsh financial restrictions or when it needs to build credibility immediately. In contrast, the latter type is often preferred when the government has enough time to design high-quality measures. As back-loading entails a form of adjustment that is generally time-consuming, the responses need to be credible enough to positively alter the country's risk premium with a high debt level. Hence, the timing of the policies is quite essential for the desirability of the ultimate achievements.

The government's aspiration to reduce public debt to the desired level determines the amount of time it will take to reach that level. Suppose the government is impatient about reducing debt. In that case, the consequence of such a front-loading policy will be very high levels of primary surpluses for several consecutive periods. Such a policy design could be detrimental for economic society because it will have to involve immediate tax hikes or a severe reduction in government spending. However, in the case of back-loading, the debt stabilisation is achieved with a smooth transition, but also the associated costs are also smoothed and are spread over time. Thus, the fiscal authority needs to bear in mind the associated costs of the speed of adjustment when calibrating the fiscal reactions (Dinçer & Özdemir, 2009, p. 125).

Besides their undesirable effects on the government budget, the overall macroeconomic indicators also languish due to fiscal reactions. In the preceding section, it was assumed for simplicity that the growth rate, interest rate etc. are constant over time. However, in the real world, those parameters are closely intertwined with fiscal reactions. Fiscal consolidation affects economic growth via a multiplier channel. If the multiplier is large, the output will be reduced substantially. In addition to that, fiscal consolidation also influences debt by changing the risk premium. A successful fiscal consolidation reduces the risk of default. It thereby improves the government's credibility, which lowers the interest rates and consequently increases the GDP level by stimulating investment.

Conversely, depending on the extent of automatic stabilizers, economic growth enhances the primary surplus. Even though the government revenues go hand in hand with economic progress, the spending can increase in an economic recession, especially in countries with large social aids in the form of automatic stabilizers such as job loss insurance or transfer payments. Hence, the primary balance worsens in a downturn. Besides, if the multipliers are high, then the economy behaves in a Keynesian manner, and the impact of fiscal consolidation on aggregate demand becomes larger. Therefore, higher multipliers decelerate the growth by quite a large margin. Such a scenario is sometimes called a *"doom loop"* in the fiscal literature (Mullineux, 2014, p. 14).

In this case, a "loop" between fiscal reaction, lower growth and the higher deficit is established in the economy. Primarily, such a loop is created unintentionally by the policy makers through unfounded pessimism pumped into the economy. This prolonged pessimism leads to hysteresis and ever falling GDP levels. In such a case, the economy faces a higher deficit and thereby higher debt level than the intended lower levels thereof. Not surprisingly, risky investments and hazardous fiscal policies which initially give rise to increased growth and profitability may well end up with a bankruptcy followed by an inevitable collapse of the financial sector. Usually, such defaults are followed by a bailout.

However, as it does not address the real structural flaws of the system, it only helps the cycle grow with no genuine regulations, which ultimately gives rise to a crisis in perpetuity. Therefore, it proves crucial for the policy makers to choose the proper form and timing of intervention to establish debt sustainability.

1.2.5 Shortcomings and Limitations of Debt Sustainability Analysis

Up to now, we have discussed several aspects of debt sustainability analysis. However, despite being useful and comprehensive, the analysis suffers from serious shortcomings and limitations as well. Gray et al. (2008) list these shortcomings as follows:

- A climbing debt/GDP does not always indicate an unsustainable debt path. According to them, public debt may also increase due to consumption smoothing, investment projects and economic reforms beneficial for the economy. Besides, once properly designed and implemented, such expenditures might generate return eventually, even though they can increase public debt in the short run. The only requirement of the fiscal reaction theory is a positive reaction to pay off the increasing debt that omits the future return of investments. These future returns may occur even in the absence of a positive fiscal response and curb future public debt deviations, which could otherwise be unsustainable.
- The fundamental concern of the debt sustainability analysis is the stabilization of the debt ratio ignoring the value around which it will stabilize. Most of the time, the debt sustainability analysis focuses mainly on stabilising public debt instead of the value it converges to. Nevertheless, especially in developing countries with low assets, the value around which debt stabilises is also quite important.
- The currency and maturity composition of the debt is oftentimes neglected in the debt sustainability analysis. Suppose the government alters its debt position by lowering the portion of short-term foreign currency debt and enhancing the portion of the national currency debt with longer maturities. In that case, the overall riskiness of the government will be reduced dramatically, even though the amount of total debt remains constant.
- The debt sustainability analysis does not take the assets and liabilities of the country into account. Some of the highly indebted countries possess a significant amount of assets in several forms that improve their capacity to pay. However, the debt sustainability analysis relies solely on the GDP as the indicator of the country's ability to repay, which restricts the analysis for most countries. Besides, the contingent

liabilities are also oftentimes excluded from the analysis as well. This type of liabilities generates additional outlay on the budget should the associated risks occur. The shifts in these assets and liabilities take part in determining the threshold level of debt in the economy, but most of the time, they are neglected and left out.

- The debt sustainability analysis does not distinguish between foreign and local currency-denominated debt risk. However, this distinction is essential because the sovereign government can only control its own currency-denominated debt, therefore, it is more vulnerable to the risks arising due to the foreign currency swings. As a result, in order to avoid a possible default, the distinction between these two types of debt should be made clear.
- Volatility and uncertainty should be incorporated into the analysis more intensively as the economies, especially the emerging ones, are under direct exposure to the volatility in the world economy. Higher volatility in the external world leads to a higher chance of a default for the emerging markets. Thus, the sustainable level of debt is directly linked to the external shocks from the rest of the world. The countries which face sudden stops of international financial flows tend to have less sustainable debt trajectories. Hence, a proper debt sustainability analysis should incorporate external shocks into the model.

Even though those criticisms are in a way sensible, it should also be noted that incorporating all these issues into analysis entails a tremendous amount of data and information, which makes the analysis extremely sophisticated and challenging to implement; therefore, the research in this book is partial in this sense.

CHAPTER TWO

LITERATURE REVIEW ON THE EMPIRICAL APPROACHES TO PUBLIC DEBT SUSTAINABILITY

In the literature, there are several tools and techniques to choose from regarding the debt sustainability analysis. Still, for a large array of reasons, some of those models are not appropriate for the practical analysis of public debt sustainability. At the same time, the fiscal reaction function appears to be the most suitable model for this purpose. Therefore, this chapter exclusively concentrates on the theoretical and empirical literature on the fiscal reaction function to disclose the underlying reasons for the appropriateness of the fiscal reaction function for the analysis and discusses how the other models compare.

Given these concerns, the objective of this chapter is twofold. Firstly, the chapter covers the alternative methods used for public debt sustainability analysis in the literature. Secondly, it gives a review of the theoretical and empirical literature regarding fiscal reaction function.

2.1 Selected Methods for Assessing Public Debt Sustainability

2.1.1 IMF Framework for Debt Sustainability Analysis for Market Access Countries (MAC-DSA)

The IMF MAC-DSA framework is a tool designed in the form of a template that facilitates the procedure of the fiscal policy design and the surveillance in market access countries. It was initially published in 2002 and was modified in 2013 with a more rigorous approach.

The MAC-DSA can be thought of as an operational tool that has been used by the officials with some country-specific modifications. As the name suggests, the market access countries are the ones that can borrow in the international market, should they need funding. Those countries are primarily advanced economies and also emerging economies such as Turkey.

The MAC-DSA is an inherently forward-looking tool that is based on a baseline scenario and calibrated realistic shock scenarios to test whether the debt is compatible with low default risks and high growth. As it is forward-looking in nature, it aims to project the potential trajectories of debt and analyse the explosiveness of public debt in a definite time horizon. The MAC-DSA incorporates other macroeconomic variables into the analysis in a forward-looking manner to test if the solvency conditions are likely to hold in the future by employing a probabilistic judgment (IMF, 2011, p. 6).

In other words, the MAC-DSA is essentially a forecasting tool with a risk-based approach in mind. Such an approach proves useful to determine the country's riskiness and the level of scrutiny needed to supervise the economy. For instance, the MAC-DSA offers high scrutiny if the projected level of debt/GDP is around 50 % for an emerging economy and 60 % for an advanced economy.

The reports are prepared based on alternative scenarios that are likely to prevail during the analysis. Apart from the regular macroeconomic variables, the MAC-DSA also incorporates contingent liabilities to reach more country-specific results. The calibration of contingent liability shocks is performed in the current case of the country in mind. In addition to contingent liabilities, several other shocks are tested on the fiscal stance of the economy to simulate the circumstances surrounding the economy realistically. As an outcome, the vulnerabilities of the economy can effectively be portrayed in the template (Jha, 2012, p. 24).

In the MAC-DSA model, the debt dynamics is characterized by the following equation;

$D_{t+1} = [(1+\epsilon)(1+r^f)DF_t] + (1+r^d)DD_t - PB_{t+1}$ where;
DF_t: Foreign currency denominated debt
DD_t: Domestic currency denominated debt
r^f and r^d are the foreign and domestic interest rate, respectively
ϵ: the exchange rate differential where $\epsilon = (e_{t+1} - e_t) / e_t$

According to that formula, upswings in both interest rates bring about an increase in the total debt. Also, domestic currency depreciation and the primary surplus reduction result in the same outcome.

The MAC-DSA is generally based on the fiscal variables scaled by the capacity to pay. Therefore, they use a version of the above equation scaled by GDP.

$$d_{t+1} = \frac{(1+\epsilon)(1+r^f)}{(1+g)(1+\pi)} df_t + \frac{(1+r^d)}{(1+g)(1+\pi)} dd_t - pb_{t+1}$$

Rearranging they get;

$$d_{t+1}(1+g+\pi+g\pi) = (1+\epsilon)(1+r^f)df_t + (1+r^d)dd_t$$
$$-(1+g+\pi+g\pi)pb_{t+1}$$

As $d_t = df_t + dd_t$, they get,

$$d_{t+1}(1+g+\pi+g+\pi)$$
$$= d_t + \epsilon(1+r^f)df_t + (r^f df_t) + r^f df_t + r^d dd_t)$$
$$-(1+g+\pi+g\pi)pb_{t+1}$$

However, due to data limitations, it might be hard to estimate this equation directly. Therefore, assuming a ratio of ϕ for the foreign currency-denominated debt, and defining the interest rate as $\hat{r} = \phi r^f + (1-\phi)r^d$, they obtain the IMF MAC-DSA type fiscal reaction function as follows;

$$d_{t+1} - d_t = \frac{1}{1+g+\pi+g\pi}[\hat{r} - \pi(1+g) - g + \epsilon\phi(1+\hat{r})]d_t$$
$$- pb_{t+1}$$

Among the components on the right-hand side, the denominator is constantly positive. So, public debt increases whenever $\hat{r}$ rises, the currency depreciates, or the share of foreign currency-denominated debt level builds up. On the contrary, the debt will decline with inflation, economic growth and primary surplus (Jha, 2012, p. 29).

The IMF MAC-DSA approach considers the time path of debt under different scenarios, including the baseline. Various scenario alternatives can be calibrated using the template, based on the forecasts of interest rate, inflation, growth and other variables. Also, the template allows the simulation of various shocks hitting the economy, such as contingent liability shock, exchange rate shock etc. A five-year horizon of the public debt can be simulated with country-specific scenarios using the template. Running this kind of stress test is the complementary element of the IMF approach. Portraying the riskiness of public debt in terms of explosiveness is the ultimate goal of the MAC-DSA approach.

Nevertheless, despite its profound strengths, the IMF approach suffers from some limitations as well. For example, changing the forecast of one variable does not alter the forecasts of the other variables in the model. Also, the number of variables that are allowed to vary endogenously are very limited. Thus, the template itself and the stress tests are seemingly restricted. Furthermore, it allows improbable events to be incorporated into the simulation. For example, the case under which one or two variables move two standard deviations, but others remain constant, is unlikely to occur. Also, the sensitivity analysis within the IMF framework does not account for the possible responses of the fiscal authorities to the debt dynamics (Burnside, 2005). In this sense, the IMF approach is not quite an alternative to the fiscal reaction function. Another reason why the MAC-DSA is not preferred is that it requires a substantial amount of time-series data that is not available for every country. Based on these two shortcomings, the MAC-DSA approach is not preferred for the analysis.

2.1.2 Barnhill and Kopits Value-at-Risk Approach

Another model in public debt sustainability literature is the Value-at-Risk model by Barnhill and Kopits (2003). Their approach involves uncertainties about the variables, including primary balance, growth or interest rates etc. The sustainability analysis inherently contains some degree of uncertainty as the predictions about the unknown future have to be made by the researchers. The Barnhill-Kopits model aims to incorporate associated uncertainty into the analysis. The Value-at-Risk approach is originally used in portfolio analysis, whereby the potential losses of existing portfolios can be calculated. It computes the worst likely loss of the portfolio for a given period and a given confidence level. To illustrate the point, we can consider an example. If we say that the one year 90 % loss of a portfolio is one thousand, then the annual loss on the portfolio is greater than or equal to one thousand with a probability of 10 %.

Barnhill and Kopits (2003) use this analogy of corporate finance to test the sustainability of public finances. They simulate potential scenarios and conditions to evaluate the likelihood of worst-case scenarios. In their model, Barnhill and Kopits (2003) treat the country as a firm. Their ultimate goal is to determine the government's net value and calculate the probability of that value hitting negative levels, which can also be considered the probability of a default using the firm analogy. In this sense, they provide a unique and original way of analysing public debt sustainability. In this model, they try to test the ways under which the macroeconomic fluctuations and contingent liabilities affect the sustainability of the fiscal stance. The analysis is based on the public sector's income structure, which also incorporates the monetary issues.

$Y_t = T_t + N_t + S_t - G_t - rB_{t-1} = Z_t + S_t - rB_{t-1}$ where,

T_t: Taxes minus transfers
N_t: Revenue from resource sales
G_t: Government expenditures
r: Interest rate
B_t: Total debt outstanding
Z_t: Primary balance excluding seigniorage

In addition to those variables, they also incorporate the contingent liabilities C into the analysis, which can arise due to purchase guarantees of large infrastructure investments, pension funds, natural disasters etc. According to Barnhill and Kopits (2003), the net worth of the government today is the net discounted value of the summation of its income structure above.

$$V_0 = PV(Z') - PV(\Delta C) - B_0$$

$$V_0 = \sum_{t=0}^{\infty}(1+r)^{-t}Z'_t - \sum_{t=0}^{\infty}(1+r)^{-t}\gamma_t \Delta C_t - \sum_{t=0}^{\infty}(1+r)^{-t}\Delta B_t$$

where,
Z' : Primary balance under the existing fiscal system
γ_t : The probability of the contingent liability ΔC_t to occur
ΔB_t : Amortization schedule of existing debt

They additionally assume no discretionary adjustment in tax and spending schemes along with the assumption of zero seignorage. If the net value is calculated to be non-negative, they conclude that the government is solvent and the associated fiscal policies are sustainable. They link the net worth to the intertemporal budget constraint. According to them, if $V=0$, the intertemporal budget constraint binds. Net worth hinges on present and potential future levels of total income, domestic and international interest rates, exchange rate and domestic and international price levels. By simulating those variables, the net asset and liability of the government can be estimated. Furthermore, the Value-at-Risk measures can be calculated on those simulations.

Nevertheless, despite being a useful and innovative approach, the Value-at-Risk approach also suffers from some shortcomings as well.

- Primarily, the future risks may not be properly estimated by constructing the variance and covariance of those variables based on past data. This point can also be exacerbated by the fact that risk modelling can only be recalibrated by expert judgements.
- Secondly, the likelihood of contingent liability shocks is not modelled comprehensively, and in reality, it is highly challenging to do so.
- Thirdly, the model suffers from data limitations as well. The model requires an extensive data set containing assets and liabilities, which are not available for many countries.
- Finally, it is based on very stringent assumptions, which reduce its sensibility.

Due to these shortcomings, the Value-at-Risk approach is not as practical as the other models. Nevertheless, once properly calibrated and satiated with sufficient data, it might reveal interesting and inspiring results for further research.

2.1.3 General Equilibrium Model

Moraga and Vidal (2004) assess debt sustainability in a general equilibrium setting in their influential paper. They design their model using an overlapping generations model with endogenous growth. In this model, endogenous growth originates from the productive effects of expenditures on education. The contribution to human capital improves efficiency. Unlike the IMF and Value at Risk models, the general equilibrium setting allows the interest rate and growth rate, which significantly impacts the long-term sustainability of the public finances, to be determined endogenously within the model. The proof of sustainability in this model is the existence of equilibrium in each period.

The setup is comprised of three sectors: households, firms and the government. The households are assumed to live for three periods. The sources of utility for those households are their consumption and the wage expectations of their children. They finance their consumption, saving and spending on education by their income earned through labour. The individual's human capital is determined in the first period by her parents' human capital and education spending. The process of formation in human capital is the driving force of the economic growth in the model. Firms use human capital and physical capital for production. In each of these three periods, firms choose a combination of inputs and maximise their profit. The government levies taxes, makes transfer payments, runs government expenditures and services existing debt along with interest payments.

By means of two differential equations, Moraga and Vidal (2004) portray the evolution of debt and capital with respect to human capital. They calibrate the model according to their human capital expectations in the EU in the near future. They conclude that human capital and demographic changes lead to unsustainable situations unless they are backed up with fiscal policy alterations. Convenient amendments to the fiscal policy secure fiscal sustainability only in a new equilibrium.

However, although the general equilibrium model is very innovative and contributes to the argument by adding new dimensions through its strong theoretical background, it also has several shortcomings such as;

- The impact of various shocks and changes can be tested within the model, but it is not convenient for the practical investigation of public debt sustainability.
- Also, it is challenging to calibrate the model in the beginning, and once calibrated, the generational adjustments and the scarce data issues impede the operational application of the model. As a result, the empirical literature on this setting is, in fact, relatively narrow.

Nevertheless, this technique does not appear to be a suitable model for practical purposes once those challenges and shortcomings are considered. However, once calibration and time horizon issues are overcome, it can reveal insightful arguments for the debt sustainability analysis.

2.1.4 Models Based on the Time Series Properties of the Data

Economic models involving debt sustainability are generally based on time series data because time-series properties of the data possess loads of useful information about debt sustainability. Public debt, government revenue, government expenditures, primary balance, taxes etc., were some examples of variables whose time-series properties were tested for debt sustainability analysis in the literature. The basic idea behind analysing the time series properties of those variables is to examine as to whether the country meets the intertemporal budget constraint in the long run. Stationarity and cointegration tests were largely used for this purpose. Despite several criticisms, this type of modelling has been used extensively in the literature since the mid-90s by several authors.

The mainstream analysis of this sort pretty much relies on the theoretical issues we mentioned in the previous chapter. As we noted earlier, the sustainability of public debt is primarily related to intertemporal solvency. The existence of solvency is essentially a function of the behaviour of the fiscal variables. For solvency to exist, the fiscal series need to keep behaving the same way as they did in the past. If the components of fiscal policy tend to divert from their normal pathway, the fiscal posture of the economy heads towards unsustainability. The sustainability of the budgetary position hinges on the preference between public debt and taxation.

The literature on the time series approach to public debt sustainability is to a large extent based on the logic described above, and the academic contributions are plentiful in this field. This section will evaluate the time series-based contributions concerning the debt dynamics in the first chapter.

The budget constraint can be formulated as follows:

$$D_0 = \sum_{j=1}^{N} \left(\frac{1}{1+i}\right)^j PB_j + \left(\frac{1}{1+i}\right)^N D_N \qquad (3)$$

This equation inherently contains essential standards for debt sustainability, but has to be restricted to avoid Ponzi schemes. The restriction is the transversality condition;

$$\lim_{N\to\infty} \left(\frac{1}{1+i}\right)^N D_N = 0 \qquad (5)$$

By imposing this restriction, the debt dynamics equation becomes;

$$D_0 = \sum_{j=1}^{\infty} \left(\frac{1}{1+i}\right)^j PB_j \qquad (6)$$

The last two equations can be used for evaluating the sustainability of public debt by testing their time-series properties. According to those equations, the value of public debt should amount to the summation of primary surpluses in the future. The present value of the public debt needs to be zero in the infinity. So, one can test the stationarity of the public debt and its first difference to make inferences about public debt sustainability. If they are stationary, then sustainability can be assumed for public debt.

In addition to the stationarity, the cointegration can also be used to test the sustainability of the public debt by employing some auxiliary variables to make Equation (3) more operational. Assuming that the real interest rate is stationary with mean *r*, Afonso (2005), for instance, defines two variables;

$$E_t = G_t + (r_t - r)D_{t-1}$$
$$GG_t = G_t + r_t D_{t-1}$$

Then, he plugs these variables into the budget constraint and gets;

$$GG_t - R_t = \sum_{s=0}^{\infty} \frac{1}{(1+r)^{s+1}} (\Delta R_{t+s} - \Delta E_{t+s}) + \lim_{t \to \infty} \frac{D_{t+s}}{(1+r)^{s+1}} \quad (16)$$

As it clear from the first chapter, the second component on the right-hand side of Equation (16) has to be zero in the limit to secure fiscal solvency. This condition inhibits the speed of growth of debt to be smaller than that of the interest rate. In the first chapter, this case was defined as no Ponzi scheme, which is a prerequisite for the intertemporal budget constraint to bind. Additionally, this equation can be used to test sustainability via cointegration. No Ponzi condition implies that GG_t and R_t should be cointegrated of order one for their first differences to be stationary. This condition can be examined by running $R_t = a + bGG_t + u_t$.

If the two series are cointegrated, then the u_t must be stationary. Obviously, if GG_t and R_t are already I(0), the fiscal policy is automatically sustainable. Yet, if the degree of stationarity is different from each other, the fiscal policy will not be sustainable. On the other hand, if these two variables are cointegrated, public debt sustainability is guaranteed.

However, in the literature, there is a considerable dispute among economists, including Bohn (1998), on the definition of sustainability and the interpretation of the coefficient b above. In general, if $b < 1$, government expenditure growth is faster than the revenues, and there occurs sustainability without bounding the debt/GDP. If $b = 1$, then there is still sustainability, but it is bounded, and finally, if $b > 1$, there is no sustainability.

Apart from Afonso (2005), another seminal contribution to the argument was proposed by Hamilton and Flavin (1986). This model aims to test whether the budget constraint is met so that the sum of the discounted primary surpluses is equal to the existing value of public debt. They also incorporate the No-Ponzi scheme condition with some bias and impose the restriction that the future stream of public expenditures will be higher than revenues. Formally, instead of setting $\lim_{n\to\infty} \rho^n D_{t+n} = 0$ they impose the constraint $E_t\left(\lim_{n\to\infty} \rho^n D_{t+n}\right) = A_0 > 0$, which implies that the public debt at least partially will not be paid back in the limit where ρ^n is the discount factor. The A_0 term is the proportion to be covered by the households rather than the government, which clearly violates the No-Ponzi condition. According to them, $A_0 = 0$ condition is only met when the primary surplus and the debt series are stationary.

This argument's main point is that if the primary balance series is stationary, it oscillates around a stable equilibrium. In order for $A_0 = 0$ to occur, the stationary primary balance needs to fluctuate around zero, which in turn leads to the stationarity of the public debt. The other outcomes cause A_0 to be greater than zero and thereby lead to a violation of the No-Ponzi scheme. Non-stationarity in primary balances and/or public debt implies $A_0 > 0$, and consequently, the discounted debt does not converge to zero in the limit. For the empirical analysis, they use annual US data of discounted primary balance and public debt.

Another chief contribution to the literature from the time series perspective is Trehan and Walsh (1988). They slightly modify the model of Hamilton and Flavin (1986) and introduce the total deficit rather than primary balance as the variable of interest. According to them, Hamilton and Flavin (1986) approach does not apply to the context of growing economies. The reason is that according to the authors, assuming stationarity for the primary balance of these countries is nonsense. Also, the debt in those countries is hardly stationary. Hence, they apply a more generalised approach to sustainability and assign a stochastic behaviour to the state revenue and expenditures. The rest of the logic remains the same, and they are also interested in as to whether the public debt in the limit converges to zero or not. Furthermore, they claim that the sustainability of the public debt can still be achieved if the debt series is integrated of order one or formally, $D_t \sim I(1)$. They also assume nonnegativity for the real interest rate. A cointegration of revenues and expenditures can evidence the stationarity of the budget deficit.

Formally, if $(rD_{t-1} + G_t) \sim I(1)$ and $T_t \sim I(1)$, then finding a cointegrating equation among these two variables would imply the stationarity of the budget deficits in the long run. The remarkable contribution of Trehan and Walsh (1988) to the theory of debt sustainability is that, unlike Hamilton and Flavin (1986), they argue that the stationarity of the primary balance series is not sufficient for the sustainability of the fiscal balances.

Later, Wilcox (1989) augments the A_0 argument of Hamilton and Flavin (1986) by questioning the potential changes in the debt sustainability analysis when A_0 turns out to be a stochastic process. He claims that it is still possible to meet the intertemporal budget constraint with a non-stationary public debt series. Non-stationary debt series can occur since the divergences of the debt from the future stream of primary balances last for long periods. Hence, the existence of a unit root in the debt series might still be compatible with public debt sustainability.

Another contribution to the theory of public debt sustainability within a time-series approach is the 1991 paper of Hakkio and Rush. They build their analysis on Trehan and Walsh (1988) above. Similar to Trehan and Walsh (1988), they also seek a cointegration between revenues and spending of the government. However, unlike them, Hakkio and Rush (1991) assume a stochastic process for the interest rate. In order to obtain an operational model, they make some amendments in the intertemporal budget constraint and get the following equation;

$$\Delta D_t \equiv G_t + r_t D_{t-1} - T_t$$
$$= \rho^n E_t \left(\sum_{n=1}^{\infty} \Delta T_{t+n} - \sum_{n=1}^{\infty} \Delta S_{t+n} \right) + E_t \left(\lim_{n \to \infty} \rho^n \Delta D_{t+n} \right)$$

where $\rho^n = \frac{1}{(1+r)^n}$ is the discount factor and $S_t = G_t + (r_t - r)D_{t-1}$ is the total spending.

As it can be noticed, they use deficit rather than primary balance for analysis. Also, they assume that the T_t and S_t are non-stationary series with drift. Formally, $T_{t+n} = \alpha_1 + \varphi_1 T_{t+n-1} + \varepsilon_{t,1}$ and $S_{t+n} = \alpha_2 + \varphi_2 S_{t+n-1} + \varepsilon_{t,2}$. Obviously their first differences will be stationary;

$$\Delta T_{t+n} \equiv T_{t+n} - T_{t+n-1} = \alpha_1 + \varepsilon_{t,1} \text{ and } \Delta S_{t+n} \equiv S_{t+n} - S_{t+n-1} = \alpha_2 + \varepsilon_{t,2}$$

as $\varphi_1 = \varphi_2 = 1$.

By defining $\alpha \equiv \sum_{n=1}^{\infty} \rho^n (\alpha_1 - \alpha_2)$ and imposing the No-Ponzi scheme condition, they end up with the following equation;

$$T_t = \alpha + \beta(G_t + r_t B_{t-1}) + \varepsilon_t$$

which is the equation they use for cointegration analysis.

The economic inference they make out of this equation is that spending and revenues are random walk processes, but if they have a typical long-run pattern, then it is safe to conclude that the No-Ponzi condition is satisfied. The reason is that the existence of a common long-run pattern indicates that the government responds to the debt movements by adjusting revenues, spending, or both to avoid Ponzi schemes.

Trehan and Walsh chips in the string of argument once again with their 1991 paper. In this paper, the authors define the necessary and sufficient conditions for sustainability as the cointegration between deficit, public debt and the expected real interest rate, which is greater than zero;

$E_t(r_{t+n}) = r > 0$ and $(G_t - T_t) - \beta B_{t-1} = \varepsilon_t \sim I(0)$ and $(G_t - T_t) - \lambda(G_{t-1} - T_{t-1}) \sim I(0)$ for some $0 \leq \lambda < (1 + r)$.

Their analysis's economic implication is that the speed of growth of the deficit is lower than the interest rate. According to them, if this happens, then the No-Ponzi scheme condition is satisfied.

Quintos (1995) contributes by introducing the distinction between weak and strong sustainability. Effectively, he combines the findings of Hamilton and Flavin (1986) and Hakkio and Rush (1991). He states that the debt series needs to be I(0) for strong sustainability to occur. From Hakkio and Rush (1991) perspective, it corresponds to first order cointegration between expenditure and revenue with the cointegrating vector of (1,-1). Weak sustainability relaxes the restriction on the cointegrating vector by imposing (1, -$\hat{\beta}$) whereby $0 < \hat{\beta} < 1$.

This condition implies that the first difference of deficit turns out to be stationary. However, as a result of this, the debt series turns out to be an I(2) process since;

$$\Delta D_t = r_t D_{t-1} + G_t - T_t = (1 - \hat{\beta})(G_t + r_t D_{t-1}) + \alpha + \varepsilon_t \sim I(1).$$

As a result, according to him, $D_t \sim I(2)$ condition supports the weak sustainability condition because the $0 < \hat{\beta} < 1$ restriction leads to $E_t\left(\lim_{n\to\infty} \rho^n \Delta D_{t+n}\right) = 0$ which is the famous No-Ponzi scheme condition. The distinction he makes between weak and strong sustainability is that the weak condition leads to a convergence of debt to zero mean with a slower pace compared to strong sustainability (Quintos, 1995).

Even though several other studies can be named which apply similar approaches to the debt sustainability analysis, it is quite clear that this sort of analysis is not very informative. According to Bohn (1998), time-series based analysis is flawed in terms of conclusions about debt sustainability for various reasons. One of the reasons why time series-based analysis might fail to reach sensible and insightful results is that the unit root tests themselves are not as precise as they need to be for such an analysis. Relying solely on the stationarity tests might bring about severe flaws and misleading results since the arguments are based solely on imprecise test outcomes. When conducting research on debt dynamics, the formal tests might reveal mixed results since they lack the power and precision to determine stationarity, especially in small samples. Bohn (1998) indicates that debt/GDP and primary balance/GDP ratios frequently exhibit prolonged persistence making it very tough for the formal tests to spot the unit roots.

In the same paper, he claims that stationarity can in fact, safely be assumed for those series. He argues that, at least in the U.S, the real interest rate was always below the growth rate. He also adds that if differencing brings them back to stationarity, the researchers should not be concerned with the stationarity of those series. He claims that if that happens, then the government will eventually meet the intertemporal budget constraint.

Similarly, Marcellino and Faverino (2005) indicate that despite mixed results from the Augmented Dickey-Fuller test, they assume stationarity for the variables following the line of reasoning of Bohn (1998). They stress the weakness of the ADF test when the sample size is small. Their sample size is relatively short (42 observations), considering the data requirements for the ADF to perform precisely.

In short, the shortcomings of the time series-based approach can be summarized as follows:

- By the very design, the formal tests are prone to misleading results as they test ad hoc sustainability by nature.
- Another challenge associated with the time series approach is the fact that they are intuitively backwards-looking. They assume that the future will possess the same properties as the past, which is obviously too stringent an assumption, especially for developing countries like Turkey. Also, they don’t offer guidance for the reaction needed to secure sustainability. As we stated earlier, Bohn (1998) has concerns about the time series-based analysis and

challenging structure of unit root testing. According to him, the design of the unit root tests makes the analysis more ambiguous, unlike the fiscal reaction function, which directly tests the way systematic fiscal policies impinge on the public debt.

- Finally, as Bohn (1998) notes, the time series-based analysis is unable to spot the reason for a falling debt. The debt might fall due to effective fiscal policy response, or simply the reason might be a random occurrence of some favourable external conditions. Failing to distinguish between the two, the time series-based analysis is far from reaching sensible conclusions, unlike fiscal reaction functions.

2.1.5 Fiscal Reaction Function

Considering the above-mentioned shortcomings of the time series approach, Bohn (1995) and Bohn (1998) propose a new model-based approach to debt sustainability, namely the fiscal reaction function. He investigates the soundness of fiscal policies in balancing the rising debt/GDP ratio by adjusting the primary balance next period onwards. In this manner, he challenges the time series methodology which is based solely on the time-series properties of the data. According to him, these tests are not convenient ways of testing public debt sustainability since they might reveal misleading results because of the weaknesses of the unit root tests.

Challenges to reject the unit root primarily originate from the very characteristics of the debt/GDP ratio, which intrinsically contain more information than the budget balance. Hence, the debt/GDP ratio might rise or fall due to the design of the fiscal policy and other factors affecting the dynamics of debt, which might lead to flawed conclusions about the sustainability of the public debt. A prominent example, at this point, is the interest rate. Most of the time, the real interest rate is not under the government's direct control, but it still has a remarkable impact on the debt/GDP ratio. Because such auxiliary factors directly affect the dynamics of the public debt, the scope of the debt sustainability analysis should definitely and solely be extended. The impact of the fiscal policy design on the debt realizations is accounted for in the analysis. Even the regular fluctuations and standard shocks to the GDP or the real interest rate might impair the time-series properties of the debt series. The vulnerability of the time series properties makes it harder for the formal tests to reject the unit root might lead to misleading conclusions on mean reversion.

Hence, it is essential to build a more comprehensive model to test the sustainability of public finances. The fiscal reaction function model possesses the strengths required for such an analysis. Simply, this model is based on the decomposition of the debt/GDP ratio and focuses solely on the systematized primary balance reactions to the fluctuations in public debt. Unlike time series-based testing, this approach merely concentrates on the design of the fiscal policy whereby the government reciprocates to the swings in the public debt by tuning the primary balance in the current and upcoming periods.

The generalized form of fiscal reaction function takes the following form;

$$(t_t - g_t) = \beta d_t + AZ_t + \eta_t \qquad \text{where,}$$

Z_t is the vector of cyclical elements that might have an impact on the fiscal behaviour of the government and $\eta_t \sim NIID\ (0, \sigma^2)$. The cyclical elements might include output and expenditure gaps (Haber & Neck, 2006, p. 3). In some papers, including Burger et al. (2012) and Greiner et al. (2007), instead of d_t, the lagged values of debt/GDP ratio are included in the estimation as an explanatory variable. The reason for including the lagged values of d_t is that the governments perform their budgets annually and when they attempt to respond to a rise in d_t by means of primary balance improvements, they can only do so in period $t + 1$. Besides, in addition to the cyclical elements, other variables such as lagged values of primary balance or squared or cubic forms of d_{t-1} can be incorporated into Z_t. In this setting, Z_t should be designed accurately and the regressor $\hat{\beta}$ needs to be positive and statistically significant to ensure sustainability. The economic intuition of a positive $\hat{\beta}$ coefficient is that, so as to respond to a rise in the debt/GDP ratio in the previous period, the government needs to improve the primary balance in the current period in order to revert the public debt to its trajectory.

According to Bohn (1998), a positive response is sufficient for debt sustainability regardless of other conditions. However, Canzoneri et al. (2001) claim that the response should be non-negative throughout the sample range for securing fiscal sustainability. From an operational point of view, this rule is obviously quite restrictive and unrealistic. Instead, there are more resilient propositions regarding the decision rule in the context of time-varying parameters. One of the contributions in this sense is the Greiner and Fincke (2015) and its earlier version Greiner and Fincke (2009). They make a proposition regarding the decision rule for sustainability in the context of time-varying coefficients. If the coefficient is positive "on average" throughout the sample, it is sufficient for debt sustainability. If the response coefficient happens to be negative on average, then the public debt becomes explosive and divergent. This line of reasoning has also been discussed by Bohn (1995). However, a straightforward proposition and its proof are included in Greiner and Fincke (2009). From a fiscal policy perspective, by modelling the primary balance and other components separately, the fiscal reaction function captures the sole response of budgetary authority to up and downswings in the public debt. Focusing merely on the dynamics of public debt from the perspective of budgetary policy design is effectively a more comprehensive way of conducting fiscal sustainability analysis.

From a theoretical perspective, the time series-based models such as Hamilton and Flavin (1986), Trehan and Walsh (1985) and Quintos (1995) are based on the stationarity of fiscal variable data, or alternatively, they test the cointegration between government revenues and expenditures. These techniques are needed to prove that the present value of the public debt converges to zero at the limit. Furthermore, the No Ponzi Game condition implies that any order of integration of public debt series lead to the fulfilment of $E_t\left(\lim_{n\to\infty}\rho^n D_{t+n}\right)=0$ condition (Bohn, 2007). The level of integration is irrelevant in this sense. In other words, he has algebraically proven that if $D_t \sim I(m)$ for $m \geq 0$, then $E_t\left(\lim_{n\to\infty}\rho^n D_{t+n}\right)=0$ (Bohn, 2007).

Bohn (2007) criticises the above-mentioned studies since they do not incorporate the higher-order integration of variables into the analysis. He also proves that the cointegration between revenues and expenditures are not needed for the No Ponzi condition to hold. Hence, according to him, any finite integration of revenue and expenditure variables will suffice for the intertemporal budget constraint to bind.

Formally, if $T_t \sim I(m_T)$ and $(G_t + r_t D_{t-1}) \sim I(m_G)$ for any $m_T \geq 0$ and $m_G \geq 0$, then $D_t \sim I(m)$ and $E_t\left(\lim_{n\to\infty}\rho^n D_{t+n}\right)=0$[1] (Bohn, 2007).

As a result of these findings, Bohn (2007) concludes that time series techniques such as unit root and cointegration are not convenient and are insufficient to reach an intuitive conclusion about fiscal sustainability. The primary reason is the tendency of these techniques to misleadingly indicate some degree of integration for debt series, which leads to the conclusion

[1] Curious readers might refer to Bohn (2007) for detailed algebraic proof.

that the No Ponzi condition has been satisfied, although it may or may not be the case.

Hence, Bohn (2007) suggests that instead of time series-based techniques, the fiscal reaction function needs to be used as a means to investigate the sustainability of public finances. Testing the existence of systematic responses of the government to debt fluctuations is more intuitive when it comes to debt sustainability analysis. However, according to Bohn (2007), the order of integration still possesses some degree of economic intuition since it gives insights into the fiscal policy performance of the government. According to him, higher order of integration implies higher macroeconomic risks in the long term.

It can be stated that according to Bohn (2007), the assessment of the quality of the public finance should not be demoted to the mere assessment of the time-series properties of the fiscal data. Instead, the fiscal reaction function needs to be incorporated into the analysis. Public debt sustainability can more properly be implemented by focusing on whether the government puts a sufficient effort to react to the oscillations in the debt ratio through primary balances. The primary reason for incorporating such an extension to the analysis is that the univariate time series analysis might lead to erroneous results about the sustainability features of the fiscal stance of the economy. The examples of such flaws include a diminishing non-stationary debt ratio which could be identified as unsustainable, or a trend-stationary debt ratio, which would misleadingly be classified as sustainable, just to name a few.

In view of these arguments, it can be concluded that the fiscal reaction function quantifies the responsiveness of the government to the key elements of debt dynamics in the economy. This line of reasoning points out that the dependent variable of the fiscal reaction function will be the primary balance, and the explanatory variables will be the previous year's debt and an indicator of the economic activity such as the output gap. Additionally, several studies include the autoregressive term of the primary balances as an explanatory variable to account for the inertia in the primary balance in the literature. Even though many other economists concur that additional variables are needed, modifications appear to be country-specific, and the data limitations mostly reshape them.

In its reduced form, however, Bohn's equation can be formulated as follows:

$$pb_t = \rho d_t + \beta_0 + \varepsilon_t$$

It is clear from the articulation above that this function aims to quantify the fiscal reactions to the debt dynamics. Bohn realized that even if the debt/GDP ratio turns out to be unsustainable, the government applies some corrective actions to smooth it and consequently brings it back to the sustainable path. Thus, insofar as we can prove the existence of such a remedial effort, we can conclude that the debt will eventually converge to a tolerable level (Bohn, 1998).

Based on these considerations, for the numerical analysis in this book, the fiscal reaction function designed by Burger et al. (2012) is used. The authors apply the fiscal reaction function to the fiscal data of South Africa to test the existence of such positive corrective action by the government. They employ a model with the lagged values of the debt/GDP with annual data, which is also convenient for the Turkish economy because the government budget is prepared on a yearly basis in this country as well. Hence, it is more suitable to use lagged values of public debt in the equation with annual data for Turkey. In other words, the sensible data need to have an annual frequency and lagged values of public debt need to be used to serve the very purpose of the analysis. Also, the two countries are seemingly similar in various aspects. For instance, both countries are classified as developing countries, and their economies are characterised mainly by instabilities. Besides, the recent economic history of both countries involves long sequences of negative real interest rates, and volatility in the growth rate is another feature in common for those countries. Thus, it is appropriate to use this version of the fiscal reaction function as a tool for analytical research from a practical perspective.

At this point, to obtain a function suitable for estimation, it is worthwhile to review the steps through which Burger et al. (2012) derive the equation for estimation.

They start with the debt dynamics, namely Equation (9) in chapter one.

$$\Delta d_t = (\phi_t - 1)d_{t-1} - pb_t \text{ where } \phi_t = \frac{(1+r_t)}{(1+g_t)} \tag{9}$$

Then, they rearrange it to obtain the level of primary surplus, which will keep the debt/GDP ratio unvaried.

By setting $\Delta d_t = 0$ they get,

$$pb_t = \left(\frac{r-g}{1+g}\right)d_{t-1} = \alpha d_{t-1}$$

where $\alpha = \frac{r-g}{1+g}$.

They indicate that this fiscal rule can be estimated as a fiscal reaction function, using actual data.

$$pb_t = \alpha^* d_{t-1} + \varepsilon$$

In the estimated version, they add the primary balance inertia as an explanatory variable as well as the output gap, whose estimated coefficient indicates the reaction of fiscal authority to the pressure from the economic activity. As a result, the authors end up with the following workhorse model of fiscal reaction function, which is suitable for estimation;

$$pb_t = \beta_1 + \beta_2 pb_{t-1} + \beta_3 d_{t-1} + \beta_4 \hat{y}_{t-1} + \varepsilon_t \qquad (17)$$

The most crucial coefficient above is obviously the β_3 which measures the size of the fiscal reaction. Provided that the value of this coefficient is positive, the fiscal policy is deemed sustainable. In contrast, a negative value of the coefficient implies a fiscal response that has destabilizing effects on the debt path. An upward movement in the primary balance as a reciprocation to an increase in debt actually makes the debt/GDP a mean-reverting process. As the government takes corrective reciprocations in the form of primary balance improvements to cope with the mounting debt, the public debt ratio declines and reverts towards its mean. Therefore, by forcing the debt to revert to the mean, the government guarantees public debt sustainability. Hence, it is crucial to test whether the β_3 is positive to examine the sustainability of public debt. Excluding inflation and seignorage, this test is the most suitable and efficient way of coping with rising debt as the central banks are independent in modern economies.

This approach is especially suitable for developing economies like Turkey for several reasons.

- First, the design of this function is more flexible than other models in the sense that it solely aims to determine if the government is performing sufficient effort to adhere to the intertemporal budget constraint.
- Furthermore, no assumptions are needed about the interest rate, making it practical for modelling developing country data. Bohn (1998) argues that the government's positive reciprocation contains valuable information about sustainability even without incorporating the interest rate and growth. In the literature, however, there are large

disputes about this topic. Some authors, including Ewijk et al. (2013) and Greiner et al. (2015), are advocates of more stringent requirements for public debt sustainability.

- Additionally, the model allows for the integration of the economic fluctuations into the model, which is extremely important for modelling a developing country's economy. Obviously, the developing countries are more prone to economic shocks and volatilities. Thus, this feature of the model proves beneficial for the results to be more intuitive and accurate (Ghatak & Fung, 2007, p. 523).

However, some caveats at this point are worthwhile to mention. According to the tax smoothing model by Barro (1974), it is not sensible to run primary surpluses on a perpetual basis to service public debt as it requires hiking taxes continuously, which is against the postulations of the tax smoothing argument. Yet, refraining from running positive corrective fiscal responses to debt fluctuations might lead to explosive indebtedness, which is also detrimental to the economy. Hence, the fiscal authority has to make substantial judgements about the pros and cons of alternative policies before implementation.

Additionally, one of the shortcomings of testing the above model per se is that it will reveal a result that is free of a time dimension. In order words, the results from the above equation will be time-invariant. However, Bohn (2008) hinted about the time-varying properties of the government's fiscal responses to the debt dynamics. The intuition behind imposing time-variation is that the government can alter its fiscal corrective efforts depending on the circumstances and shifts the policy choice accordingly. Also, it might not be possible to run a positive fiscal reaction in the case of adverse economic conditions, which contributes to the time-varying nature of the fiscal reactions. In chapter one, we touched upon the uncertainty pertaining to the conditions surrounding the debt sustainability analysis. However, time-invariant models will fail to capture these uncertainties and the time-varying nature of fiscal responses.

Additionally, the more the debt/GDP ratio raises due to changing outside conditions, the more extensive the fiscal efforts need to be to bring it back to its stable path. Thus, it is clear that the government's corrective fiscal response is a contingent action that requires a time-varying estimation procedure. Hence, expecting a fixed coefficient and a positive sign for the entire range of observations would be too stringent and unrealistic.

Instead, there are more resilient propositions regarding the decision rule in the context of time-varying parameters. One of the contributions in this sense is the Greiner and Fincke (2015) and its earlier version Greiner and Fincke (2009). They make a proposition regarding the decision rule for sustainability in the context of time-varying coefficients. If the coefficient is positive "on average" throughout the sample, it is sufficient for debt sustainability. If the response coefficient happens to be negative on average, then the public debt becomes explosive and divergent. This line of reasoning has also been discussed by Bohn (1995). However, a straightforward proposition and its proof are included in Greiner and Fincke (2009). They extend the argument to be more precise about the decision rule for public debt sustainability. A positive coefficient does not necessarily indicate that the debt/GDP ratio will remain steady or converge to level zero. There are other conditions that need to be fulfilled for sustainability to be reached. In particular, in addition to a positive sign of the fiscal reaction parameter, the magnitude of the coefficient needs to be larger than the interest rate and growth rate differential for convergence to occur. According to this approach, Bohn's condition is rather a weak requirement for sustainability, and a more substantial requirement needs to be fulfilled by the government to have a sustainable debt position.

2.2 Some Empirical Examples of Fiscal Reaction Function

In the preceding section, the featured methods in the literature to test public debt sustainability, including fiscal reaction function, were introduced, and the reasons why the fiscal reaction function is preferred over the other models were figured out. In this section, the objective is to outline the empirical literature related to the practical modelling of the fiscal reaction function to comprehend the results and model variations in other countries to reconcile the contribution of this study to the literature. Because the fiscal reaction function has been introduced to the literature by Henning Bohn, it is convenient to start this section by reviewing his empirical works before going through the variations applied by other authors.

Bohn (1995) and Bohn (1998) criticized time series-based approaches on several accounts, especially about their stringent assumptions about the indicators' time-series properties. Hence, instead of an analysis based solely on time series properties of fiscal variables, he methodologically proposes to test the existence of a systematic positive response in the form of primary balance improvements to rising public debt. According to him, a positive reaction mechanism in the government's primary balance policies can be interpreted as a good indicator of mean reversion in public debt. Following this line of reasoning, Bohn (1998) introduces this reduced form equation for testing.

$$s(t) = vb(t) + Z(t)\alpha + \epsilon(t)$$

He argues that the sustainability of public debt is associated with the positive values of v in the above equation. If this condition holds, the government does not need to bear mounting costs associated with rising interest rates on public debt on every round because it covers debt with raised revenues. The main advantage of such a model over time series-based approach is the ability to decompose the reasons behind the falling debt ratio. The flexibility in Bohn's approach in testing the existence of positive reaction makes it particularly suitable for developing countries. In other words, this approach has superiority in modelling developing country data over the univariate analysis as the latter is susceptible to volatility and fluctuations in the economic data.

In the empirical section of Bohn (1998), he applies this technique to U.S. data from 1916 to 1995. In this study, his research mainly focuses on the existence of corrective measures to react to accumulating debt. According to him, the underlying reason in the debt ratio movements needs to be determined to make inferences about the status of public debt sustainability. This type of testing does not require assumptions about the interest rates and is suitable for economies surrounded by uncertainties and malfunctioning debt management problems. The ground for a decline in public debt needs to be a policy design rather than a random occurrence of a favourable event to secure sustainability. He claims that there is strong evidence for corrective actions to the movements in public debt. The debt/GDP ratio is surrounded by several uncertainties making the rejection of unit root harder for formal tests. Therefore, to overcome this issue, Bohn (1995) suggests that some control variables should be added to the equation to account for the cyclical fluctuations. In this case, a positive response of primary surpluses is adequate for sustainability in a weak perspective. Based on the evidence of his empirical estimations, public finances have been sustainable in the US despite long periods of primary deficits that are controversial to the former methods involving univariate time series.

In order to extend the equation to account for the indicated cyclical fluctuations, he proposes the inclusion of the tax smoothing approach in Barro (1974). If no other explanatory variables are added to the equation, regressing the primary balance on public debt will bring about omitted variable bias, leading to inconsistent estimates. Under this setting, Bohn calculated four fiscal reaction functions for different periods using OLS. His findings indicate that even though the formal tests imply non-stationarity in the public debt series, there are counter fiscal reactions to public debt in the U.S. that are increasing function of the debt/GDP. Consequently, the debt/GDP becomes a mean-reverting process since the control variables regarding cyclical fluctuations are added to the equation. His findings reveal results in favour of sustainability with positive and statistically significant values of the reaction parameter. This result indicates that the primary surplus reacts positively to upward movements in public debt, guaranteeing intertemporal solvency and sustainability. He opines that this signal for sustainability is obscured in univariate time series analysis by wartime spending and cyclical fluctuations. He also shows that the findings in univariate analysis are ambiguous and inconsistent as they do not account for the fluctuations in income.

Barrow (1979) and Kremers (1989) were unable to prove mean reversion in public debt, which, according to Bohn (1998), is a misleading conclusion. He concludes that, contrary to the findings of the univariate time series approach, the U.S. public debt is sustainable, provided that the interest rate and growth move favourably for debt dynamics. Overall, this paper shows that the U.S. government has been performing positive reactions to upward movements in the debt/GDP ratio by means of primary balance improvements from a historical perspective. Such a positive response implies a mean-reversion in spite of the contrary results from formal stationarity tests, which are misleading since they are not adjusted for fluctuations in GDP. Based on these findings, according to Bohn (1998), the fiscal reaction function can be used as a new tool for testing sustainability in government debt.

Later, Bohn (2008) contributes to the argument by formally outlining the proposition regarding public debt sustainability criteria. In this paper, which could be considered as an extension to Bohn (1998), Bohn focuses primarily on the importance of the growth rate in public debt sustainability. The heightened capacity to pay, which is an outcome of economic growth, is a key determinant of sustainability in public debt. The unit root tests performed on the unscaled debt and primary balance series reveal misleading results due to heteroskedasticity.

For this reason, he claims that the most credible evidence of sustainability is the existence of robust positive responses, primary balance scaled by GDP to the upward movements in debt/GDP. This paper offers several extensions to the fiscal reaction function theory, such as general equilibrium setting, non-linear estimations, and time-varying estimation. The fiscal manoeuvrability of the government is bounded by the level of risk aversion of the lenders. Therefore, no matter how sustainable the fiscal policy is in a country, there can be sequences of periods in which borrowing is challenging for the authorities. Thus, he suggests setting up a general equilibrium model to account for the behaviour of lenders in an overlapping-generations setting.

Another extension he proposes is the time-varying estimation to reinforce the argument about sustainability. In this setting, public debt's coefficient needs to be greater than zero and remain in the positive zone for a large portion of the data set. He states that stable feedback in a time-varying setting guarantees sustainability, but unstable feedback is indicative of unsustainability in the public debt. Another extension he offers is the exclusion of seignorage from the primary surplus to guarantee that the solvency is not obtained with financial repression or monetization. Empirically, Bohn (2008) extends the data set to cover the interval between 1792 and 2003 and incorporates new variables into the equation, such as output gap and lagged values of primary balance and debt/GDP. Once again, his findings indicate the government's robust positive reaction to lagged values of public debt, which is an indicator of sustainability. The empirical evidence suggest that growth realizations covered the interest payments on U.S. debt throughout history.

Apart from Bohn himself, there are several other contributions to the argument with specific variations. Celasun et al. (2006), for instance, estimated a panel fiscal reaction function using data from 34 emerging markets. They employ a probabilistic approach to assess public debt sustainability by constructing a fan chart. This approach is convenient to account for the magnitude of risks associated with the country's indebtedness, which arises due to the uncertain nature of economic events and policies. Their approach involves a simulation algorithm for the debt dynamics involving shocks to several variables and the government's counter policy responses. They emphasize the role of fiscal dynamics in designing the risk profile of the debt. Combining the effects of shocks and endogenous fiscal policies, they build fan charts that are basically probability distributions for each year. Their approach involves a seemingly versatile structure that can be standardized for various countries. Their data set covers the period from 1990 to 2004. Their results indicate that only five of the 34 countries (Turkey, Brazil, South Africa, Mexico, Argentina) exhibit signals of sustainability indicated by positive response coefficients. Their algorithm consists of three blocks in which the shocks are calibrated based on the historical data. Based on quarterly data, they set up an unrestricted VAR model using the determinants of public debt. Obtaining the conditional variances and covariances, they generate projections for the variables determining the public debt path. Secondly, they estimate a fiscal reaction function in a panel data setting. According to them, the panel approach is not suitable for fiscal reaction function theory. If sufficiently long data sets are available, the estimation of fiscal reaction function needs to be country-specific.

The third step combines the first two blocks and produces annual projections of growth, interest rates, exchange rate, and public debt. By means of repeating simulations, they construct forecasts for each year, and they exhibit the results in a fan chart which involves the projections of public debt into the future. This paper's prominent feature is its ability to endogenize the uncertainty in the public debt sustainability framework by incorporating a probabilistic approach rather than the conventional deterministic approach. According to their findings, the probability of a 10 % rise in the debt/GDP in Turkey from 2005 to 2009 was around % 30. During this period, no such dramatic increase in indebtedness occurred in Turkey, which is in line with their findings. However, the fan charts generated in the paper are indicative of the fact that the debt profile of the country is vulnerable to outside shocks under different shock calibration scenarios.

Greiner et al. (2007) apply the fiscal reaction function to selected Euro Area countries. The countries they choose are either highly indebted countries or those that violated the Maastricht criteria more than once. They apply the methodology proposed by Bohn (1998). Their evidence indicates that despite some violations of the Maastricht criteria, the countries pursue fiscal policies consistent with debt sustainability. They put sufficient fiscal effort to trim the fluctuations in the debt/GDP ratio. However, the authors claim that stabilising debt via primary balance improvements lead to a reduction in public investment, which is not favourable for developing countries. Therefore, they state that high debt ratios may turn out to be a hindrance to economic growth in the long run.

Budina and Wijnberger (2007) combine different fiscal sustainability approaches to generate a tool for assessing fiscal sustainability in modern economies. They join the probabilistic simulations with steady-state analysis. Their approach also aims at determining the required fiscal adjustments by interpreting the stochastic simulations of exogenous variables. They test their tool using Turkish data. They generate an indicator to test public debt sustainability. This indicator is called the required deficit reduction based on the projections of growth, interest rates and debt/GDP ratio. Besides, they account for the inconsistency between fiscal and monetary policies. This approach links inflation, fiscal deficits and public debt management for augmenting the analysis by incorporating the interaction between the policies. Like Celasun et al. (2006), they run stochastic simulations, calibrated shocks, and stress tests. Combining this set up with a fiscal reaction function, they retrieve interesting results for Turkey. They run a fiscal reaction function for Turkey and calculate the reaction coefficient consistent with debt sustainability definitions. However, they caveat about Turkey's debt structure. According to them, there is a potential risk of rollover due to Turkey's precarious structure of public debt.

Mello (2011) investigates the sustainability of public debt in Brazil through fiscal reaction function. He uses a Monthly data set from 1995-2004 for this purpose. The paper concludes that the Brazilian government reacts to the changes in the debt position by readjusting the primary balance accordingly. He states that with the introduction of debt ceilings in the country in 1998, the fiscal authorities could exert a higher level of response to debt movements. According to him, the government generated fiscal efforts even during periods of slower economic activities. To ensure sustainability in debt dynamics, the Brazilian government improved primary balance by hiking revenue and cutting public investment rather than reducing expenditure which could have deteriorating effects on economic performance. This paper's findings imply that the government responded to upward movements in debt in general and local levels. Also, especially at local levels, the scale of fiscal reaction is affected by institutions and regulations, including the ceiling on indebtedness. Overall, he concludes that public debt is sustainable in Brazil based on the fiscal reaction function's estimation results. However, to preserve public debt sustainability, the government needs to keep running primary surpluses continuously. According to the author, to make the country less vulnerable to adverse shocks, the continuum of primary surpluses is essential for this country. Altering the composition of debt is also beneficial in reducing the riskiness of government finance.

Fincke and Greiner (2011) estimate the fiscal reaction function to test the debt policies' sustainability by elaborating the coefficient sign of lagged debt in the model for several Euro area countries. They use penalized spline estimation to obtain the time-varying coefficients of fiscal efforts. Their findings indicate that the conducted fiscal policies are sustainable in those countries except for Greece and Italy. This paper is an augmented version of Greiner (2007) by the incorporation of a time-varying setting. According to the authors, the data generating process is nonlinear and uncertain.

Therefore, transforming the OLS model in Greiner (2007) into a time-varying setting brings the model closer to the actual data generating process. Also, the time-varying setting enables the detection of any change in the parameter. It facilitates the analysis to determine as to whether it is positive for the entire range or not.

Stoica and Leonte (2011) analyse Greece's fiscal troubles in the post-Euro currency adoption period. For this purpose, they run a fiscal reaction function similar to the one we described above. Their data set covers the 2001Q1-2008Q2 period. However, they reach insignificant coefficients for the output gap and primary balance. Their interpretation is that the results indicate a malfunctioning fiscal policy, which is one of the causes of the current dire economic conditions in the country.

Afonso and Jalles (2011) establish a fiscal reaction function for OECD countries using a VAR model to estimate fiscal responses. Their results point out that the OECD countries raised primary surpluses when they face an increase in debt following a Ricardian policy.

Burger and Marinkov (2012) estimate the fiscal reaction function in Markov-Switching and GMM frameworks for South Africa. By comparing the estimated time-varying coefficients with the real interest rate growth differential, they draw the inference that the model provides sufficient evidence to conclude that the fiscal position in South Africa is sustainable. They build a framework with anchored flexibility in the fiscal rules. Considering the difficulties of forecasting macro variables, they propose a fiscal rule that sets a target level for fiscal variables. According to the authors, the government can put a target band for the variables to test sustainability. In this case, even though the government can deviate slightly from fiscal targets, it does not lose its credibility. According to their calculations, the government in South Africa ensured sustainability in the near history.

Kapopuolas and Lazaretou (2012) investigate the public debt sustainability in selected SEE countries in a comparative manner. They figure out that the selected countries pursued efforts to reach successful fiscal positions according to their estimations. However, according to them, the link between public debt sustainability and those fiscal policies is relatively weak. They estimate a pooled cross-section fiscal reaction function with GLS for seven countries, including Turkey, for the 1998-2008 period. According to the authors, unlike other countries, the interest rate and growth environment were not favourable for debt reduction during the sample.

Despite being positive and significant, the primary surplus was insufficient to return the public debt to sustainable levels. They find that at low levels of debt, the primary balance responds to public debt positively. Still, as the public debt level increases, the strength of the fiscal reaction falls, indicating fiscal fatigue.

Burger et al. (2012) elaborate on the way South Africa responds to its debt position. They use various methods to estimate the fiscal reaction function (OLS, TAR, State-Space, VECM etc). Their findings imply that the South African government has exerted proper corrective fiscal efforts to stabilize debt position from the 1990s onwards. According to their results, since 1946, the South African government performed well in improving primary balance to reciprocate to rising debt. The authors claim that the government's past performance in reacting to the upward movements in public debt gives a hint about the future trajectory of the country's fiscal policies. Based on the estimations, they run forecasts about the path of public debt in the following years. According to forecast estimations, public debt will remain sustainable in the near future. All estimation techniques reveal positive fiscal reaction coefficients, which support the idea that public debt is sustainable in South Africa. Also, the output gap parameter is positive, indicating a countercyclical fiscal policy in the country. The autoregressive term in the equation has a positive coefficient that signals inertia in fiscal management. According to the TAR model's estimation results, the authors test the strength of a fiscal reaction in different business cycle phases with solid evidence for countercyclical fiscal policies. Also, fiscal sustainability is evidenced by the government's positive reactivity, and for the estimation period, the cost of borrowing remained moderate, which facilitated public debt management. Since the formal tests of stationarity provide imprecise results about unit root, they estimate the function in VECM form, assuming non-stationarity in the series. The estimation results from the VECM form are also consistent with former estimations and are in favour of sustainability. They calculated an error correction term equal to -0.445, which indicates the existence of a fiscal reaction to the departures from the long-run trend in fiscal variables. According to that, in the period following the deviation, nearly half of the deviation is corrected.

The authors also test the fiscal reaction's stability by running a state-space version of the fiscal response involving the evolution of the reaction parameter over time. They set the fiscal reaction parameter as a random walk and the other variables as time-invariant. According to estimation results, the output gap parameter is once again negative, indicating countercyclical fiscal policy as in the case of former estimations in the paper. Up to the 70s, the reaction parameter remains below zero consistently. According to the authors, the negative actual interest rates during the period facilitated debt management. Therefore, the government muted the fiscal reactions as they were in a way not needed. Since the 1970s, the parameter has risen continuously, which indicates a stronger fiscal reaction each year. The authors attribute this improvement in the indicator to the rising real interest rate in the economy, requiring a more robust response to trim the excessive upward movements in the debt/GDP ratio. They claim that even though the snowball effect turned negative recently and alleviated the implementation of debt management strategies, the fiscal reaction is still strong in South Africa. The favourable snowball effect coupled with a solid fiscal reaction coefficient gave rise to a substantial decline in the public debt to GDP ratio. Throughout a large portion of the modern history of South Africa, the fiscal policies have shown a remarkable degree of responsiveness to upward movements in public debt sufficiently to preserve sustainability. Although the degree of responsiveness varies in time, the variations are in harmony with the developments in the economy.

In addition to these estimations, the authors also use the fiscal reaction function as a data generating process to run forecasts about the future course of public debt to GDP ratio. By running one thousand random simulations of possible debt trajectory, they account for the inherent time variability in the nature of public debt management. Their methodology is based on Celasun et al. (2006). They calibrate the forecasts based on the parameter values estimated by OLS and TAR variations. Based on these forecasts, they generate fan charts to evaluate the future trajectory of public debt.

Along with the simulations of fiscal variables, they forecast the real interest rate and the GDP series required for constructing a fan chart. They repeat the bootstrapped simulation a thousand times and calibrate the fiscal reaction function with these simulated values to construct fan charts and thereby obtain the distribution of budget balances and public debt. According to these calculations, the probability that the debt/GDP will remain under 50 % in 5 years is around 90 %. Their overall conclusion is that the South African Government tightened the fiscal policies whenever they faced shocks to the debt/GDP ratio. However, this reaction exhibits time-variation and the government mutes it when the snowball effect is favourable, while it strengthens the fiscal reaction when the snowball environment turns negative. They also claim that with some exceptions, the government generated surpluses above the debt stabilising level. They conclude that it is improbable that the public debt's future trajectory will be explosive in South Africa. However, the government's choice between stabilising debt and stabilising output will determine the future pathway of the public debt.

Mauro et al. (2013) constructs a panel data version of the fiscal reaction function with 55 countries. They calculate rolling coefficients to test public debt sustainability. Their findings reveal that whenever a country has a debt/GDP above the threshold, unanticipated falls in growth lead to less powerful increases in the government's fiscal reactions.

Weichenrieder and Zimmer (2013) also estimate a panel version of the Bohn (1998) approach on selected Eurozone countries to test whether the Euro membership has reduced the fiscal response coefficient's magnitude compared to the pre-euro era levels. Their data set covers the 1970-2011 period and 17 countries. Their findings suggest that there is no systematic reduction in the prudence level of fiscal policies when the pre and post Euro accession periods are compared. However, country-level analysis reveals contrasting results since the debt level of countries differ substantially.

Mahdavi (2014) runs a fiscal reaction function on 48 American states. His coefficient estimations imply robust evidence in favour of sustainability in selected American states.

Plödt and Reicher (2014) use the fiscal reaction function as a baseline model for projecting the future values of public debt and primary balance. Their forecasts are based on the estimations of the fiscal reaction functions. They run their simulations under different scenarios in different confidence intervals. By doing so, they can determine the required level of the primary balance to corresponding simulated debt levels.

Mutuku (2015) estimates a fiscal reaction function for Kenya. He uses a data set from 1970 to 2013. According to his findings, there is no systematic behaviour in Kenya's fiscal policy, leading to the conclusion that the public debt in Kenya is not sustainable. He proposes the implementation of long-run fiscal adjustments to avoid severe threats to fiscal sustainability.

Waheed (2016) uses the fiscal reaction function to test the public debt sustainability in Bahrain. His findings conclude that the data support the idea that there is sufficient effort by the government to stabilize the public debt. The government's fiscal measures in terms of corrective steps sufficed to return the debt to its stable level whenever needed.

Nguyen et al. (2016) run a time-varying fiscal reaction function to test the debt sustainability in the U.S. For this purpose, they set up a state-space model. They aim to test whether the primary surplus/GDP responds to the debt fluctuations in a time-varying manner. According to their results, the debt/GDP ratio was sustainable until 2005. Still, in the following years, the primary balance reaction turned negative, which impairs the ability of the government to cope with debt surges. They claim that the situation got even worse during the financial crisis when the primary balance/GDP ratio kept falling while the debt/GDP ratio was rising. This paper is a prominent example of proving the inadequacy of unit root tests and time-invariant models to test public debt sustainability. This paper's unit root analysis implies public debt sustainability, whereas the time-varying fiscal reaction function model refutes sustainability.

Arsić and Nojković (2016) analyse the public debt and primary balance nexus in Serbia before and during the economic crisis. Their fiscal reaction function results imply that Serbia's fiscal efforts were insufficient to revert the debt to its stable path. They conclude that the lack of persistence in their fiscal efforts indicates fiscal fatigue. They also state that compared to the other countries in Europe, the Serbian government's strength to run fiscal measures fell more remarkably.

Belguith and Gabsi (2016) estimate a time-varying parameter model to run the fiscal reaction model. They conclude that the time-varying parameters are positive, indicating adjustments for the public debt movements.

Campos and Cysne (2019) use a monthly data set to assess the fiscal sustainability in Brazil with a time-varying fiscal reaction function. They use state space, penalized spline smoothing and time-varying cointegration techniques for their analysis. Their time-varying results indicate that the government's corrective efforts decline over time, which indicates that the fiscal response to debt fluctuations gets less intensive in a gradual manner. This falling trajectory of fiscal responses in Brazil conveys the country to an unsustainable debt position.

Vdovychenko (2017) applies the fiscal reaction function within a regime-switching model. He uses a logistic smooth transition regression for this purpose. His findings imply that the corrective fiscal efforts were active during periods of the high income gap and high debt/GDP ratio levels. However, such a shift is not frequent, and during economic growth, it is procyclical, whereas it turns out to be neutral during the stagnations.

Everaert and Jansen (2018) run a cubic fiscal reaction function to calculate the fiscal space and fiscal fatigue in OECD countries. They find out that the countries differ in terms of their fiscal reaction magnitudes, and diversity also exists in the degree of their fiscal fatigue. The primary balance/GDP exacerbates during unpleasant times and does not respond sufficiently during recoveries in OECD countries.

Makau et al. (2018) estimate a fiscal reaction function for Kenya. They claim that due to Kenya's expansionary fiscal policies, the government has failed to respond sufficiently to swings in public debt. They point out that the country needs to pass stringent laws to force the government to refrain from exerting high budget deficits and thereby design the proper response to the fluctuations in the debt/GDP ratio.

CHAPTER THREE

EMPIRICS

The final chapter is comprised of three sections. The first section provides an overview of the data by emphasizing its salient features. This section also covers a short economic history of Turkey. The second section deals with an overview of the empirical techniques used for estimation. The underlying principles and logic behind the estimation techniques are discussed from an econometric perspective in this section. The third section interprets the estimation results. In this section, the results and findings of the empirical estimations are evaluated to bring in a verdict about the sustainability of Turkey's public debt.

3.1 Overview of the Near Economic History of Turkey and Salient Features of the Data

In order to interpret the data properties thoroughly, it is worthwhile to review the recent economic history of Turkey before going through the prominent features of the data set. Thus, the purpose of this section is twofold: First, it aims to provide a brief overview of the mainstream economic events in the recent economic history of Turkey, and secondly, the distinguishing features of the data set are evaluated based on the view of the underlying economic events. The reason for following such a sequence is that the data used for analysis is the numeric outcome of the economic conditions and events in the recent history of Turkey.

3.1.1 Overview of the Near Economic History of Turkey

The political efforts for prosperity and recovery in Turkey were structured within the frameworks of five-year plans before the 70s, which gradually lost their political influence during the early 70s. The fundamental policies used in those plans included trade restrictions, investments in state enterprises and financial repression. During the implementation period of these plans, considerable economic growth was achieved through import substitution and thereby relatively good atmosphere in the economy was prolonged until 1977. However, in 1977 Turkey was hit by a harsh debt crisis, which took years of effort and negotiations to resolve. In the rest of the decade, the country suffered from severe economic contraction.

The post 70s era of Turkish economic history was primarily shaped by the financial guidance and impetus of the IMF, whilst in the pre-1977 period of the decade, Turkey had current account surpluses and high economic growth. There were, however, some discontinuities in this overoptimistic environment, mainly caused by international economic events. One of those impairing events was the fourfold rise in oil prices. As a result of two global oil crises in 1973 and 1978, Turkey was impelled to restructure its mounting debt with OECD and international banks in 1978, 1979 and 1980. However, as the international community provided no sufficient debt relief, the rescheduling caused a further increase in debt stock through the interest rate channel, let alone reducing its level. The overvalued exchange rate, large budget deficits were among the other major concerns about the economy.

As a consequence of these unfavourable external and internal events, the current account surplus was depleted, and the government found itself in a position of extreme need for borrowing. Thereafter, concerns about the sustainability of debt embarked on in Turkey. The debt profile was primarily shaped by short term external borrowing, which was obviously more arduous for the country to roll over (Celasun & Rodrik, 1989, p. 196).

For the third time in history, Turkey implemented foreign exchange stringency in 1978. The foreign lenders compelled the government to service the existing debt, which mostly had short-term maturities and also the growth rate shrank, leading to lower capacity to pay. As a result, a debt crisis became inevitable for the country. The consequences of these unpleasant developments in the economy were mounting inflation and a severe foreign exchange shortage. Hence, the unfavourable external environment, the inappropriate maturity structure of public debt and malfunctioning policies gave rise to the debt crisis in the late 70s. It can be noted that Turkey's debt sustainability problems originally started after the first oil shock rather than the second one, even though a favourable environment appeared between the two. Apparently, the adverse international issues and flawed fiscal and economic policies led to a gradual occurrence of the debt crisis over this period in the country. In other words, the debt crisis in the mid-1970s is effectively a postponed crisis characterized by the short-term debt structure of the mid-1970s. Such a debt strategy is inherently destabilising for the economy but part of the reason for excessive short-term borrowing during the period was the exchange rate guarantees provided by the government.

Interestingly, the ultimate result was a severe depreciation in local currency, which exacerbated the debt crisis even further. In fact, the situation was a quasi-Ponzi scheme. The sustainability of the borrowing strategy relied solely on the foreign lenders' willingness to pursue an interest in financing the country. However, the continuum of the influx of foreign financial resources to the government, under those circumstances, was very unlikely. Once the stream of funds decelerated, the system collapsed, and the country faced a severe debt crisis.

As a result of this debt crisis, two IMF-backed stabilisation programmes were implemented to curb the unpleasant developments in the economy in 1977 and 1979. However, the fiscal and economic policies were of little help for recovery. Besides, those stabilisation programmes and the government's efforts were not sufficient for recovery in the economy (Celasun & Rodrik, 1989, p. 197). Also, due to the economy's subpar performance, those agreements were cancelled, and another agreement was signed in 1980. Based on this agreement, until 1985, Turkey used IMF funds amounting to 1.6 billion SDR for financing the extraordinary conditions in the economy (Celasun & Rodrik, 1989, p. 201).

Furthermore, the government spending in the next periods could not be reduced sufficiently to reciprocate to the mounting debt. The undertaken policy measures were either too weak or too late to successfully react to deteriorating public debt conditions. Apparently, the depreciating effects of high interest rates dwarfed the positive effects of already low growth levels and the fiscal reactions of the fiscal authorities. Besides, under the pressure of IMF policies, Turkey implemented two currency devaluations amounting to almost 90 per cent in a very limited time. Ultimately, to cure the adverse conditions in the country, on the 24th of January 1980, Turkey embarked on a stabilisation programme that was unprecedented in terms of coverage and impact. The programme involved a full-fledged transformation of the economic system into a more liberal structure by doing away with state-controlled policies. In other words, the indicated transformation can be defined as a complete neo-liberal shift in economic management. From then on, in most aspects of the economy, the decision was left to the market forces through privatisation, deregulation and removal of the interventions which are distortionary in nature (Kepenek, 2011, p. 55).

The IMF-backed programme was accompanied by complete transformations on economic and political grounds, moving the country towards a more open-economic structure. Thus, this era can be defined as the integration phase of the economy with the rest of the world. The programme's characteristic traits included; positive real interest rate to promote savings, export promotion, incentives for foreign investors, elimination of interest rate ceilings, and implementing a floating exchange rate regime. During the subsequent years, the programme's fruitful outcomes appeared in the economy, and economic growth mounted dramatically along with the positive atmosphere regarding exports and investment. However, the government's non-commitment to implement the programme correctly prevented the optimistic environment from lasting for prolonged periods. The policy package appeared to be a bold intention. However, the ultimate results were not as satisfying as expected by the authorities (Celasun & Rodrik, 1989, p. 202). Even though there were some discontinuities in terms of economic stability, the economic indicators, including growth, improved remarkably during the first five years of implementation, and the inflation fell considerably. However, in the second half of the 80s, the same performance could not have been exhibited.

The reason for this outcome was the disciplined military management in the first half of the decade, which had a higher level of commitment to the program compared to its successor civil government. As a result of the politico-economic policies, remarkable divergence from the program took place during the mid-80s. However, it should be noted that the international community provided sizeable debt relief and new sources of financing became available, which alleviated the economic conditions. As an outcome of the financial liberalization, private banks were allowed to borrow in the international market. The foreign banks were given permission to participate in the financial transactions in Turkey. However, international financial institutions' debt relief ended in 1984, which raised public debt concerns once again in the country.

The 1980 reform, despite remarkable improvements in the economy, could not obviate the major problems of the economy, including debt servicing. As it had been initiated with debt relief, no significant amount of effort was exerted to generate a full-fledged debt strategy in the rest of the programme. In other words, the debt sustainability problems could not have been solved through this programme. Not surprisingly, the export-oriented growth programme came to an end in 1989, and a new set of liberalisation policies was put into practice which was more liberal than the programme it replaces. The first phase of liberalisation was characterized by commodity trade and exchange rate liberalisation, and the second phase was a complete financial liberalisation. Full convertibility of the TL, abandonment of capital controls, asset market and capital account liberalisation etc. were some examples of several measures implemented in the second phase. From the public financial perspective, the financial liberalisation facilitated the debt servicing needs of the country, but at the same time, it also led to a wider trade deficit in the economy (Voyvoda & Yeldan, 2015, p. 24).

As an outcome of the liberalization policies in the 80s, the country had a fully open, globally integrated economy during the 1990s. The implementation of these strategies was undertaken with the expectations of higher savings, lower interest rates and restored growth. However, throughout the 90s, these expectations remained far from being fulfilled. Financial openness facilitated the flow of international financial sources, but conversely, it made the country more vulnerable to the outside shocks and sudden stops of financial flows. Besides, it shortened the overall maturity of the debt structure. As a result, the full financial liberalisation gave rise to a series of speculative attacks from international markets targeting the financial markets of Turkey (Voyvoda & Yeldan, 2015, p. 7). Finally, the ultimate result of the increased fragility turned out to be higher interest rates, lower growth, depreciating currency, continual balance of payments deteriorations etc. The economy consequently became more fragile and susceptible; therefore, consequently faced severe financial crises in 1994 and 1998. The reason for those crises was the excessive interest payments on the maturing debt, which was mostly short-termed in terms of maturity. At the end of the decade, the public debt and servicing costs were no longer controllable in Turkey.

As the government was unable to borrow in long maturities to rollover the outstanding debt and the compounding interest payments, it was obliged to find new sources of borrowing in a very short period, which was a tough and unsustainable situation due to harsh economic conditions (Voyvoda & Yeldan, 2015, p. 9). Under the Ponzi scheme dictation, the budget was no longer able to serve its social and economic functions and lost its economic policy tool traits. Budgeting was remarkably challenging as the government could only borrow in short maturities and at high interest rates. Social expenditures such as education and health had to be suspended due to budget constraints. Therefore, on the social level, society's welfare fell dramatically. The 90s can be thought of as a combination of short growth periods followed by immediate downturns. Short term financial flows gave some temporary boosts to the economy by promoting the expenditures and consumption, but since it led to depreciation and capital account deficits, these temporary boosts were mostly followed by immediate plunges in the economy. During the bust section of these cycles, the government investments also fell dramatically, contributing to the unpleasant portrait of the economic conditions. Besides, the Asian and Russian crises in the late 90s had contagious effects on the economy's already worsened posture.

The 90s was largely characterized by the lack of fiscal discipline and insufficient political decree to focus on long-term fiscal transformation. Unsustainable levels of public finance deficits and hazardous levels of fiscal risks borne by the government were the main characteristics of the country's budgetary outlook during the decade. For instance, the public sector financing needs were to increase from 10% to 15% at the end of the decade. The major determinants of such remarkable public sector financing needs in the country were the large duty losses and the hidden factors affecting the calculations of budget deficits. As a result of these factors, the accumulated effects of duty losses and hidden financing needs intensified the impact of the economic crises at the end of the decade (Yılmaz, 2007, p. 109)

During the 90s, the budget revenues and expenditures increased at different speeds, which also increased the country's indebtedness. The ratio of budget expenditures to the GDP grew around 7%, while the average growth rate of public revenues was slightly above 5%, which caused the budget deficits to mount dramatically during this period. Consequently, disposable budget revenues turned negative in certain years and eventually, this negative trend was translated into higher public debt levels throughout the decade. Besides, the deficits of the public enterprises and social security expenses were covered by means of transfers from the central budget, which led to a further rise in the indebtedness of the country (Emil & Yılmaz, 2003, p. 11).

In contrast, the central bank policies in the 90s were designed in favour of public debt management, and the seignorage was one of the forces working against excessive debt accumulation. Nevertheless, despite its alleviating effects on public debt management, seignorage had influential adverse impacts on the economy, including heightened inflation. Besides, a real appreciation of TL against other currencies was remarkably influential in public debt management and curbed excessive upward movements in public debt to GDP ratio. Despite occasional reverse movements, during the 90s, the exchange rate facilitated public debt management in Turkey (Emil & Yılmaz, 2003, p. 35).

Between 2000 and 2004, the magnitude of the public sector financing needs was to a large extent determined by the social security deficits. The fluctuating manner of these financing needs was an important indicator of fiscal management's lack of long-term vision during this period. Consequently, the fiscal stance and public services' sustainability was threatened by the indicated short-sighted fiscal measures. Also, the banking system restructuring during the economic crisis brought about a substantial increase in the financing needs, which resulted in an even higher public debt stock at the beginning of the new decade. In addition to that, the rollover ratio was around 90% which is also indicative of high borrowing by the government from the market that had large crowding-out effects on the overall economy (Emil et al., 2005, p.39).

During the 90s, a series of recovery attempts by the government proved insufficient. The conditions got so harsh that a more extensive intervention became inevitable for the economy in the following years. In an attempt to stabilise the economy, in 1998, a widespread disinflation programme was launched by the authorities. However, two consecutive major earthquakes coupled with political ambiguities led to the failure of this programme. As a result of that failure, a new IMF-backed program was announced in December 1999. Compared to the previous programme, it was more profound and substantial in terms of coverage and structure. According to this programme, the primary balance/GDP ratio was determined as a performance indicator for the 2000-2002 period. The purpose of this programme was, as defined in the first letter of intent, to facilitate the debt stock reduction through primary surplus generation in the following years. However, in less than a year, another severe financial crisis hit the economy in November 2000. As a consequence of this crisis, the previous programme's primary balance targets were updated to higher levels (from 3.7 to 6.5), and an additional letter of intent was submitted following the implementation of *"Transition to the Strong Economy Programme"*. Nevertheless, during the early 2000s, critical deviations from the intended targets were quite remarkable, and for this reason, several additional measures were annexed to the letter of intentions during this period.

During the early 2000s, Turkey performed remarkably well in terms of primary balance generation. However, the primary balance target set by letter of intents was largely achieved by higher-income generation rather than reductions in public spending. Since the tax base was not sufficiently prominent in Turkey, primary balance generation based on government income generation gave rise to a dramatic increase in the tax burden on the economy, especially by raising the indirect tax to levels as high as 66.9 %. Along with the savings deficits in those years, the disposable income in the consolidated budget appeared to be harmful for the first time, which was financially quite restrictive for the government as far as the primary government services and transfer payments were concerned. Also, higher indirect tax rates gave rise to a deterioration in the fiscal justice caused mainly by the worsened distribution of the tax burden among the society.

Another distinguishing feature of the programme was the share of one-shot taxes levied mainly to cover the expenses aroused due to the earthquakes in 1999. Such immediate income-generating tools prove that the quality of the income generation procedure of the programme was rather poor since no profound tax system reform was established within the postulates of the programme. Even though the new government attempted to design a proper reform in the tax system on several accounts, the economic environment was not granting sufficient time for such a substantial tax system update. It was forcing the government to implement one-shot taxes to cover the immediate expenses.

Overall, it is clear that the IMF backed fiscal adjustment programmes were to a large extent based on new and immediate income generation rather than expenditure adjustments and sound reforms in fiscal management. Since it failed to apply proper rationing and partitioning in terms of expenditure design, the government was essentially prevented from using public spending as an essential policy tool during this period. In other words, the IMF programme in the 2000s faced a severe trade-off between the quality of fiscal policies and the short-term budget needs of the country arising due to economic crisis conditions. This trade-off also gave rise to a dilemma between the profound reforms and the short-term fiscal policy concerns for the policy makers, which were primarily shaped by political uncertainties, external factors, crisis environment, and fluctuating market expectations. However, the programme also brought new approaches through expenditure and income generation reforms for achieving a better overall tax system in the future. The only hindrance for implementing such a fiscal reform was the absence of a well-functioning tax system when the IMF programme was established, which eventually resulted in inconsistencies between the intended targets of the programme and the real-life experiences during the implementation period. There were several reasons for this inconsistency, including the weaknesses in the institutional capacities, deferral of reforms and measures, lack of quality in the fiscal adjustments etc.

The 1999 disinflation programme was based mainly on the pegged exchange rate and some austerity measures to establish the fiscal balance. However, in February 2001, a more prominent and severe crisis occurred in the economy. Thereafter, the government embarked on the floating exchange rate regime, which was effectively the end of the current IMF programme. To reciprocate to the detrimental effects of the 2001 crisis and to expedite the economic recovery, a new stand-by agreement was signed with the IMF. By providing financial assistance amounting to 20.4 billion dollars, the IMF, to a large extent, gained involvement in the fiscal management of the country (Voyvoda & Yeldan, 2015, p. 11). According to this agreement, Turkey was forced to raise interest rates, apply fiscal contractions, privatize state-owned enterprises, and reduce government involvement in the economy. By implementing this standby agreement, Turkey effectively set the target of 6.5% primary surplus and committed itself to the implementation of contractionary monetary policy to reduce inflation.

Obviously, the agreement's primary purpose was to minimize the repressive effects of the fiscal stance on the economy, and the primary balance was the leading indicator for this purpose. The programme envisaged a gradual decline in the debt which could only be achieved by running a primary balance sufficient to cover the excess debt rollover. For this purpose, budgetary discipline and enhancement of revenue resources were included in the programme as well. The Public Finance Management and Control Law enacted in 2003 was one of the prominent steps taken to renovate the budgeting legislation concerning all government segments.

Another remarkable feature of the programme was the 18 % real interest rate target for attracting international capital flows to Turkey (Yeldan & Ünüvar, 2016, p. 6). The most direct effect of such a target appeared on the foreign exchange market. As TL's price was being determined in the free market, the excessive flow of arbitrage seeking foreign capital caused a remarkable appreciation in the TL. The programme designers believed that the programme's proper implementation would improve the credibility of the country, which would facilitate the recovery by reducing the risk premium and borrowing costs. Such facilitation was affiliated with the program intensively, and consequently, fiscal sustainability became one of the programme's theoretical bases. To achieve this target, Turkey signed another stand-by agreement with the IMF to prolong the promising environment generated by the fiscal discipline that appeared as a result of adherence to the IMF programme.

The absence of such a well-established fiscal discipline in the 1990s had brought about severe increases in the public finance deficits throughout the decade. Those deficits (both hidden and visible) led the public debt stock to grow dramatically, heightened the financial markets' pressure, and eventually caused interest rates to rise. Higher interest rates eventually gave rise to an even higher amount of debt stock through a snowball effect. For this reason, the inevitable and primarily focused policy of the IMF programme was a transition to sustainable public finance through primary surpluses. During the beginning phase of the programme, the projected privatisation revenues and primary surpluses could not have been reached. The belated fiscal performance caused a deferral in the provision of crucial public goods and an overall deterioration in the country's economic status. Those worsened economic conditions were the grounds for the implementation of additional stand-by agreements during the early 2000s.

After the general elections in 2002, the single-party government, despite some initial hesitation, declared that it would make a binding commitment to the IMF programme with a strong emphasis on the primary balance generation. Following the programme's commencement, Turkey managed to generate remarkable primary surpluses indicating a clear shift in the primary balance performance from negative to positive during the period. Nevertheless, such a drastic and radical shift in the primary balance performance brought about concerns regarding the quality of the way this shift was established.

Focusing solely on debt reduction through primary surplus generation brought about side effects during the period since the quality of the adjustments was primarily ignored by the authorities due mainly to the dilemma mentioned above between society's immediate needs and programme reforms. Also, preserving the level of the performance in the primary balance generation at sustainable levels was quite challenging for the government since it required a substantial amount of sacrifice in terms of fiscal space over a long time, which could be very hazardous for a developing country like Turkey.

Unlike many other countries benefiting from the IMF programmes, Turkey's primary balance generation measures were based mainly on revenues rather than expenditures. Around 70 per cent of the total fiscal adjustments were related to revenue generation, whereas only 30 per cent was devoted to spending cuts and expenditure tightening. In other words, the shift as mentioned earlier in the primary balance trajectory of Turkey was largely based on increased tax revenues. However, the sustainability of a fiscal adjustment strategy hinges on the frequency of the measures implemented by the programme. One-shot measures reduce the credibility, and thereby sustainability of the fiscal adjustments becomes questionable. Interestingly, 67% of the total efforts during the early 2000s were one-shot adjustments whose effects were short-termed and not sustainable. Even though the government somehow met the programme targets, the quality and the sustainability of those adjustments were obscured by the structure of adjustments.

Until the 2008 global crisis, Turkey performed remarkably well to reduce inflation, increase growth, and generate the primary surpluses. However, this optimistic environment was largely financed by the large international financial flows to the country, which kept its pace until the 2009 global crisis. The real interest rate remained competitively high in Turkey throughout the period. Also, even though the primary balance performance was quite remarkable during this period, the short-sighted nature of the implemented adjustments led to heightened tax burdens on the economy. It increased the number of problems related to the structure of the fiscal system. The primary expenditures also went up, leading to additional concerns about the sustainability of the fiscal stance. However, for a sound fiscal adjustment, the primary expenditures should have been reduced gradually. However, compared to the 1990s, especially the transfer payments rose dramatically during this period.

The real burden of the adjustment programme was largely borne by the tax revenues in that the tax revenues increased on average by 2% and the total tax burden exceeded 26% of the GDP, which was 22% before the programme. Since the primary expenditure cuts were not as high as expected by the programme, some one-shot taxes were converted to permanent status, and some tax rates were increased, and also the scopes of some taxes were enlarged. All of these alterations had impairing effects on the real economy, particularly on production and employment. New employment and production costs rose remarkably compared to the late 90s, which created a disincentive for the private sector.

Despite occasional downward swings throughout the 2000s, the real interest rate remained higher than many developing countries, which facilitated economic performance. As a result of the overvalued TL, Turkey faced an import boom which deteriorated the current account balance. The expansion of the current account deficit coupled with a decline in savings led to a gradual decline in the performance after the 2008 financial crisis. During the IMF programme's six-year implementation period, the debt/GDP ratio kept falling remarkably to the values well below the Maastricht levels. The IMF program ended in May 2008, and thereafter no other stand-by agreements have been signed. However, only one year later, the 2008 crisis hit the entire world, and Turkey was no exception. The Turkish economy contracted by around 5 % in that year. The government's fiscal stimulus brought it back to positive levels only from 2010 onwards. Despite the prolonged growth era, the country could not keep up with other developing countries in terms of economic performance, mainly due to the persistence of high inflation rate.

In addition to the economic developments, during 2010s several political events from several sources affected the economy, including the war in Syria, political turmoil in the country between 2013 and 2016 along with the failed coup attempt which had deteriorating effects on the budget and the overall economy. However, except for the recent severe depreciation of TL against other currencies, the country's overall performance was acceptable as far as the economic indicators were concerned. However, it is clear that in recent years, the financial resources in the international market are not as accessible as they used to be in the early 2000s for Turkey, which brings about a concern for the government and pins it down to find alternative sources of financing such as extended privatisation. Although the debt/GDP ratio keeps remaining below the levels required by Maastricht criteria, the private sector's vulnerability has surged dramatically due to the volatile exchange rate movements. Construction of large infrastructure projects financed within contingent liability schemes appears to be another source of risk for the country's public finances since there is a potentially high risk of contingent payment through treasury guarantees. Purchase guarantees on those projects can bring an extra burden on the budget in the near future, which could impair the seemingly stable debt/GDP ratio.

3.1.2 Data Set

Now that we have explored the economic events of the recent economic history, this section aims to introduce the variables used for estimation along with their prominent features.

3.1.2.1 Preliminary Information About the Data

The data set covers the 1970-2017 period on an annual basis and is comprised of the following variables:

- Primary Balance (Percent of GDP)
- Total Public Debt (Percent of GDP)
- Real GDP
- Interest Rate
- Inflation
- GDP Growth Rate

The primary balance, total public debt and nominal interest rate series were retrieved from two datasets of the IMF, namely the IMF Financial Statistics Database and IMF Historical Public Debt Database. The rest of the variables were retrieved from the World Development Indicators Database of the World Bank. The longest interest rate series available was the deposit rate, which covers the 1986-2017 period. For the 1970-1985 sub-period, the central bank discount rate is used as a proxy to calculate the real interest rate.

The real interest rate was calculated by plugging the interest rate series and the inflation series into the Fisher Equation below;

$$r_t = \left(\frac{1+i_t}{1+\pi_t}\right) - 1$$

Another calculation carried out for the analysis was the output gap as a per centage of potential output. For this calculation, following the arguments in Burger et al. (2012), two different filters were employed for constant-coefficient and time-varying estimation settings. Initially, for the time-invariant setting, the Hodrick-Prescot filter is used to decompose the cyclical component of the series, and the difference was scaled with the potential output. The result was multiplied by one hundred. Following Ravn and Uhlig (2002), λ=6.25 was set for calculating the potential output because they proved that this level is the most appropriate for annual data. Secondly, for the time-varying estimation, Kalman Filter was used for calculating the output gap as indicated in Burger et al. (2012)[1].

3.1.2.2 Salient Features of the Data

Judgements regarding the sustainability of the public debt indispensably require an exploration into the past values of the economic indicators. Hence, the examination of the main trends and salient features of the data is crucial for proper scrutiny of public debt sustainability.

Primary Balance/GDP

Figure 9 below plots the primary balance/GDP ratio over the estimation period. As it is clearly illustrated in the graph, until the mid-90s, the primary balance was almost every year in deficit. This trend is obviously a fundamental reason for the financial crises in the 90s and early 2000s. During the period before the 90s, remarkable fluctuations are exhibiting short periods

[1] The computer programming codes for calculating output gap with Kalman filter are available in the appendix.

of improvements; however, despite these occasional improvements, the primary balance was negative on a continuous basis until the mid-90s. Obviously, perpetual negative primary balance clearly violates the transversality condition and is an important sign of unsustainability in public finances.

The data plot of the primary balance below can be partitioned into two subperiods. The first period until the mid-90s is to a large extent dominated by negative primary balances, whereas the second segment, from mid-90s till late 2010s, is primarily characterised by positive primary balances. During the first sub-period, three rounds of improvements and abrupt falls in the primary balance are clearly visible on the plot below. Nevertheless, high and persistent inflation rates coupled with the short-termed maturity structure of the public debt brought about negative primary balances in this segment of the data set. After the 90s, a positive primary balance was an essential tenet of the IMF programmes. The government was pinned down by the IMF agreements to generate positive primary balances continuously. Except for 2001, Turkey managed to run primary surpluses in the post-1994 section of the data, which is a good indicator for the government's efforts to correct the impairing effects of debt accumulation. However, it is clear that the visible development in the primary balance was achieved by the stringent rules of the IMF programmes. As the graph below illustrates, in the absence of compelling IMF programs recently, the government is considerably far from its past achievements. Despite the fact that the country managed to run surpluses as high as 7 % twice in history, it appears that such a performance could not have been achieved, and the country is facing primary deficits once again from 2015 onwards.

Figure 9 Primary Balance (Percent of GDP)

Source: IMF Financial Statistics

Table 1 below illustrates the average value and the range of the primary balance realizations for sub-periods of five years within the estimation period. On average, the primary balance is in surplus in the post-1994 period and in deficit during the pre-1994 period. The wide ranges during the late 90s and early 2000s imply that fiscal performance fluctuated considerably during these years. Therefore, the intervals containing these years have the most extensive ranges because, during the crisis, the primary balance hits shallow levels which are followed by rapid improvements as an outcome of the IMF interventions. Also, the relatively large range after 2006 indicates a gradual decay in the economy's primary balance performance.

Table 1 Range-Mean Statistics for Primary Balance

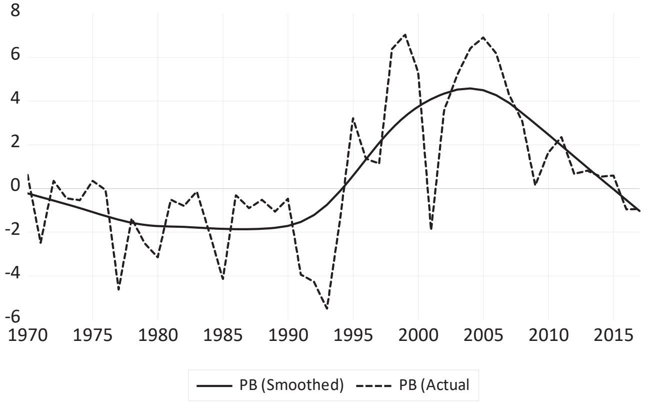
Sub-period	Range	Mean
1970 - 1975	3.09507	-0.356764
1976 - 1981	4.54303	-2.03881
1982 - 1987	3.99316	-1.39345
1988 - 1993	5.02692	-2.62614
1994 - 1999	8.48576	2.94769
2000 - 2005	8.80783	4.24984
2006 - 2011	6.04627	2.94654
2012 - 2017	1.77604	0.119368

Source: Own Calculations

Besides, the IMF backed programme after the 2001 crisis appears to work well in terms of fiscal management as the average primary balance in this period is above the rest of the sample. Debt reduction was a central tenet of the IMF programme, and the proper way of reducing debt is to run primary balances on a continuous basis. The primary balance plummeted in 2001 but in just one year increased to unprecedented levels and remained at those levels for several consecutive years, which is visible in Figure 9. Nevertheless, it is far from its past performance in recent years with an average of 0.11 per cent.

The shift in the primary balance structure over time can also be illustrated by decomposing the primary balance series. The figure below depicts the structural decomposition of the primary balance throughout the years in the sample. The dashed line on the graph is devoted to actual data, while the solid line represents the structural component calculated via Hodrick-Prescott filter and shows the part of the primary balance generated as a result of fiscal policies. The vertical distance between two lines in any year reflects the share of the primary balance appearing due to cyclical events and automatic stabilizers.

Figure 10 Structural Decomposition of Primary Balance

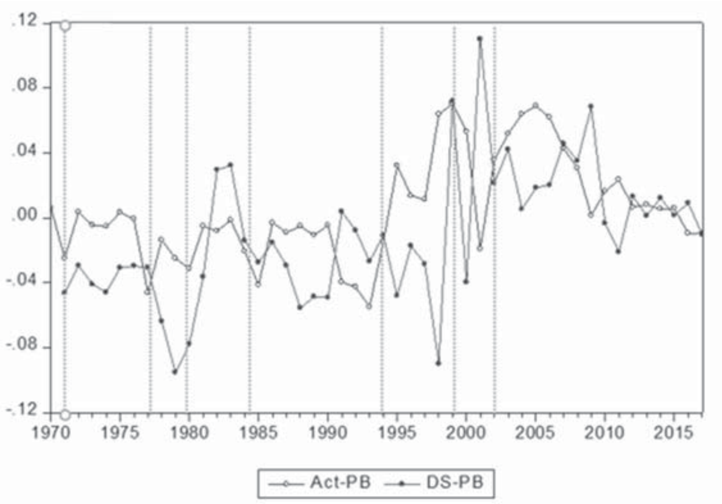


Source: Own calculations

As the graph illustrates, during the IMF program in the post-2001 period, the structural part is way higher than the cyclical component, indicating the government's fiscal responses to reduce the debt level back to stable levels under the supervision of the IMF. However, during the pre-crisis episodes of the early 90s, the partitioning is vice versa. The two components are seemingly on a par with each other indicating lower government control on the fiscal policy compared to the post-2001 era. Figure 10 also clearly shows that during the late 90s and early 2000s, the government raised primary surpluses way above its long-term trend as an outcome of the IMF programme. Still, in the post-2010 era, the downward trend in the primary balance is so apparent as well. This trend can be interpreted as an indicator of diminishing fiscal strength for preserving public debt sustainability in the country.

Furthermore, figure 11 below illustrates how the actual primary balance realizations measure up against the debt stabilising primary balance level throughout the estimation period. As we know from the first chapter, the debt stabilising primary balance satisfies $\Delta d_t = 0$ condition and hinges on several factors such as the level of public debt, availability of other debt reduction tools, and the real interest rate and growth rate differential. Thus, comparing this hypothetical level of the primary balance with the actual primary balance realizations reveals remarkable insights about the government's performance in debt management.

Figure 11 Debt Stabilising Primary Balance vs. Actual Primary Balance



To calculate the debt stabilising level, Equation (11), $pb^* = \frac{r_t - g_t}{1+g_t} d_{t-1}$ can be used by plugging the growth, real interest rate and previous period debt into the equation. The line with black dots depicts the debt stabilising primary balance calculated by Equation (11), and the line with circles represents the actual primary balance realizations. Also, the vertical lines on the graph represent the years in which a standby agreement with the IMF was signed. Seven IMF agreements are shown on the graph since other standby agreements were cancelled due to poor performance.

As can clearly be seen on the graph, there are only a few instances where these two lines overlap, indicating that the required primary balance has been just equal to the actual primary balance only a few times in history. Another point to consider is that, during the economic crises such as 2001 or 2009, the line with circles has always been below the black dotted line indicating a poor performance in terms of primary balance reciprocations. Each IMF agreement is followed by episodes in which the actual level of primary balance is larger than the required level as expected. The post-crisis episodes, where the line with black dots is remarkably below the line with circles, such as the 90s or early 2000s, point out the governments' commitment to the IMF programmes, which urged the government to generate large primary balances. Besides, in the last ten years, except for 2008, it appears that the black dotted line is slightly below the line with circles or the two lines intersect with each other, which points out to the relatively adequate performance. During the 2008 global economic crisis, however, there is a significant difference between the two values. The actual primary balance hits a value above the 0.06 level, while the stabilising level has a value of around 0.001 in 2008. It means that the government needed to generate a surplus of 6 per cent during the global economic crisis. Still, it suffered from a near primary deficit, which is an obviously prominent sign of the government's insufficient performance figure to respond to debt dynamics. It also shows how vulnerable the Turkish economy is to external shocks.

Similar arguments can be made by examining the position of the lines during the former economic downturns. During the 2001 crisis, for instance, the wedge between the two lines was extremely large that the required level was around 11 per cent, while the actual level was below zero, which corresponds to a primary deficit. Also, the first half of the 90s is primarily and, not surprisingly, characterized by remarkable differences between the actual and required primary balance levels where the required level is continuously above the actual primary balance. Besides, as illustrated by the graph, the vertical lines appear whenever the black dotted line is above the line with circles for a few years in a row. Put differently, when the government failed to generate sufficient primary surplus for a few consecutive years, the IMF standby agreements were signed in an attempt to find a short-term solution to the deteriorating fiscal conditions. However, as it is clear from the graph, the sequence of the IMF agreements is nearly periodical, indicating that the government was unable to stabilise the fiscal balances on a continuous basis.

The Turkish economy was performing noticeably well until the petroleum crisis in the late 70s, which can clearly be observed by examining the position of the lines during this period. However, the impairing effects of the two petroleum crises can also be observed in the graph. In the late 70s, the line with black dots appears above the real primary balance line for the first time after a period of seemingly good performance. However, after the crisis in the late 70s, Turkey implemented an IMF-backed recovery program, and the military government exerted strong adherence to its implications. This policy's outcome is also evidenced in the graph with the positions of the two lines. Nevertheless, in the mid-80s, the government lost the fiscal discipline indicated by considerably higher levels of debt stabilising level compared to the actual levels of primary balance.

Public Debt/GDP

Unlike primary balance, the public debt series exhibit a more stable pattern, excluding the obvious summit of 2001, where it tops out. This stable appearance of the data gives a hint about the sustainability of public debt. If we omit the 2001 summit, the debt/GDP oscillates within the 20-50 per cent band, far below the Maastricht level. Also, the relatively good performance of the economy in the first half of the 70s until the petroleum crisis can clearly be observed in Figure 12 below.

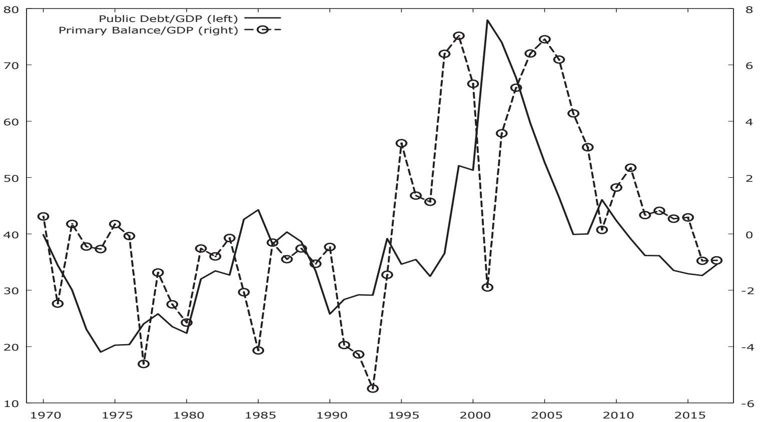
Figure 12 Public Debt (Percent of GDP)

Source: IMF

The debt/GDP steadily fell during this period, which does not, surprisingly, correspond to the rising primary balance in Figure 9. Besides the improving primary balance, the falling debt/GDP ratio in the early 70s can, to a large extent, be attributed to the negative interest rate existing in the economy. The skyrocketing rise in public debt during the late 90s and abrupt fall during the early 2000s are the most distinguishable features of the public debt series. Persistent primary deficits in the early 90s and a strong commitment to the 2002 IMF programme can be considered the grounds for those movements in the data.

Overlapping Figures 9 and 12 illustrate the subject more comprehensibly. In Figure 13 below, the rising public debt in the 90s coexists with primary deficits in the economy. Also, through the end of the decade, the primary balance improves, but the public debt keeps rising, which can be explained by the low growth rate and short-term maturity of the public debt. The year 2001 corresponds to the highest public debt and remarkably low primary balance values, and such an abrupt movement in the debt/GDP can be considered a shock on the level of debt. From a theoretical perspective, the government has to react to this shock by raising the primary balances. The government indeed responded to this shock by increasing the primary surplus, but the driving force behind this reaction was the IMF programme's impelling force. The renewed IMF agreement and strong adherence by the new single-party government brought the primary surplus to record high levels in a very short period.

Figure 13 Primary Balance and Public Debt Combined



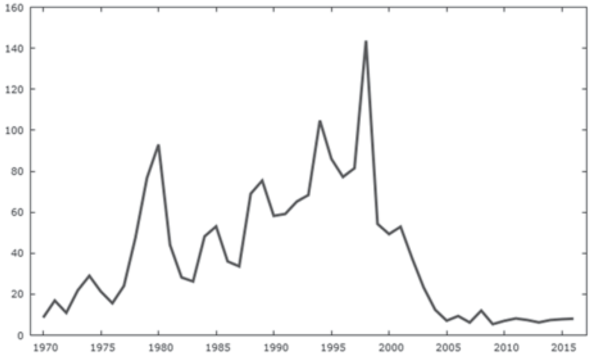
Source: IMF

Nevertheless, the 2008 crisis proved that the economy is still vulnerable to external shocks despite a seemingly stabilised debt ratio. Besides, the primary deficits and rising debt ratio in the last two years of the data raises concerns about the potential debt problems in the near future.

Inflation

The figure below depicts the inflation rate for Turkey over the period 1970-2017. A prominent structural break can easily be seen by visual inspection of the figure. Before the early 2000s, it has an upward trend despite some occasional downward movements, but after the 2000s, it is remarkably stable at seemingly low levels. The disinflation programme of the IMF during the early 2000s appears to perform well in reducing inflation. The inflation rate tops out during the 1998 crisis. Throughout this period, the government had lost control of debt management and currency devaluations, current account deficits, maturity structure of the public debt, and the contagious effects of the Asian and Russian crises all contributed to instability in the overall economy, which gave rise to skyrocketing inflation. Nevertheless, it is clear from the first chapter that the real interest rate, which is a key variable for analysis, is directly linked to inflation since the lower levels of real interest rate reduce the government's debt bill. Thus, despite its deteriorating effects on the economy, inflation might alleviate the debt position, especially when the domestic currency-denominated debt is high.

Figure 14 Inflation (Consumer Prices)



Source: World Development Indicators (World Bank)

In developing countries, unlike high-income countries, the real interest rate and growth might be negative for several years. Even though this feature facilitates debt reduction in the short run, the negative real interest rate coupled with low growth rates indicates that the debt level is not under the direct control of the government.

GDP

GDP is obviously an internal component of the main variable of the fiscal reaction function, namely the debt/GDP ratio. Being the denominator of the ratio, it has a direct and inverse effect on the indicated ratio. Any movement in the GDP alters this indicator's value even in the absence of a change in the debt level. In other words, a fall in GDP leads to a rise in the debt/GDP even if the amount of debt remains constant. Besides, the GDP is the sole indicator of the capacity to pay in the fiscal reaction function theory. According to that, a higher level of GDP indicates a higher level of fiscal space and thereby larger fiscal potential to keep public debt under control.

The structural break in the early 2000s in the GDP level is clearly visible in Figure 15 below. Strong adherence to the government's recovery programme has led to an unprecedented rise in the real GDP during this period. It is evident that the prolonged increase in GDP translates into a higher capacity to pay, which explains the fall as mentioned earlier in the debt level.

Figure 15 GDP (Constant Prices) (Billions of US Dollars)

Source: World Development Indicators (World Bank)

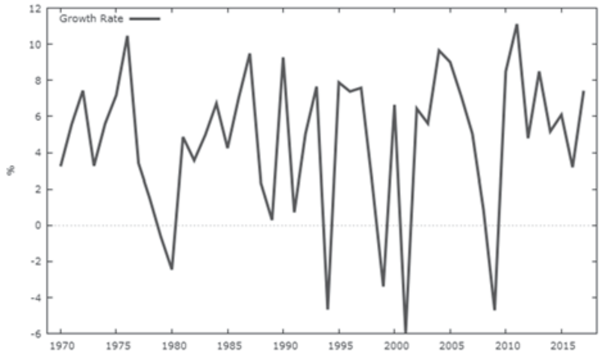
Seemingly low GDP levels have been one of Turkey's most important economic problems for the entire sample of 1970-2017. The low GDP levels were the major impelling force of rising public debt in Turkey by restricting the governments' fiscal space, especially during the pre-2000s.

Growth Level

The estimation period's growth rate is by far the most oscillating series in the dataset structured by prominent boom-bust cycles. The upward and downward swings in the growth rate are observable with clarity on the graph below. It hits negative levels during the crises, but in the rest of the sample, it is not stable either. The explosiveness of the public debt is determined by the real interest rate growth differential (or snowball effect); therefore, the growth rate needs to be sufficiently high to reduce the public debt. However,

Figure 16 illustrates that the growth rate is not stable and, most of the time, was far from being favourable for debt stabilisation.

Figure 16 GDP Growth Rate



Source: World Development Indicators (World Bank)

The Real Interest Rate

Along with the growth rate, the real interest rate is another major determinant of public debt's explosiveness. In developing countries, the real interest rate may be negative for longer periods, which can be favourable in the short run for public debt management. In Turkey, this was the case for a large portion of the data range, and the real interest rate remained negative in the 70s, late 80s and entire 90s. The obvious reason for the prevalence of negativity in this parameter is the high inflation rate throughout the sample. Only during the early 80s and early 2000s, it reaches positive values impelled by stringent regulations of the IMF programmes.

One of the IMF programmes' critical tenets was implementing a positive real interest rule to attract international funds to the country. Especially in the early 2000s, after the severe economic crisis, this strategy facilitated the recovery from the debt crisis as a considerable amount of international funds flowed into the economy. Contrastingly, the negative levels of real interest rate exacerbated the debt management problems in the 90s, as it was repelling foreign investors from purchasing government bonds in large amounts. Because of insufficient long-term international funding, the government was constantly trapped in the Ponzi schemes, which is obviously not a pleasant debt management strategy.

In theory, the negative interest rate reduces the snowball effect, which is a favourable situation for debt management as far as the existing debt stock is concerned. In the 70s, for instance, the relatively low levels of debt/GDP ratio can be attributed to the alleviating effects of the negative real interest rate. However, the emerging economies need to roll over the existing debt on a continuous basis. Thus, despite its beneficial aspects of reducing the burden of existing debt, the negative real interest rate has impeding effects on the government's debt servicing capability by providing a disincentive for foreign investors. Also, high inflation rates have devastating effects on the economy; therefore, despite its theoretical benefits, the prevalence of high inflation rates and consequent negative real interest rates are severely harmful to the economy. Moreover, the final noticeable point on the graph is that the value once again turns negative through the end of the estimation sample, which is an unpleasant signal as far as debt sustainability is concerned.

Figure 17 Real Interest Rate

Source: Own Calculations

3.2 Econometric Techniques

In this section, the econometric techniques used for the estimation procedures involving the data set covered in the preceding section are briefly explored.

3.2.1 Vector Auto Regression Model

According to many authors, including Bohn (2008), Canzoneri (2001) and Greiner (2007), estimating a time-invariant coefficient for the entire sample provides a restricted and stringent argument about the sustainability of public debt. The reason is that the concept of sustainability is inherently a time-varying process that is under the influence of continuously changing factors. However, despite their limitations, time-invariant models still have a certain degree of potential to contribute to the argument. Also, comparing the results of both types of estimations enhances the framework and improves the quality of public debt sustainability assessments. Besides, many authors, including Bohn (1998) and Burger et al. (2012), initially estimate the fiscal reaction function in the OLS format as well. For these reasons, the model was estimated in the time-invariant coefficient setting with OLS and VAR before moving on to the time-varying parameter estimations.

In Econometrics, VARs can be thought of as a set of linear equations estimated by OLS incorporating multiple variables. They allow us to grasp the combined dynamics of a set of variables by including each endogenous variable's lagged values. It is simply a generalization of the single variable AR (p) model to multiple variable cases. Besides, the VAR models extend the framework through impulse response analyses and causality tests. For this study, a Vector Auto Regression model is set up to conduct impulse response analysis to test the response of primary balances to debt dynamics with the expectation of a presumable positive response of primary balance to a shock in public debt. The VAR analysis also involves testing to determine the direction of causality among main research variables. According to the fiscal reaction function theory, the primary balance needs to respond positively to the rising debt; therefore, the direction of causality needs to be from public debt to primary balance. By means of the causality test, the direction of the causality can be determined to conclude if it is consistent with the postulates of the fiscal reaction function theory. In this part, a block exogeneity test was carried out to test the validity of the formulation of the fiscal reaction function in Turkey, given the indicated data set of macro variables.

Formally, the framework for VARs can be described as follows;

If there are n variables, then;

$y_t = \left[y_{1,t}\,, y_{2,t} \dots y_{n,t}\right]'$ is the vector of variables, and the reduced form VAR can be written as;

$$y_t = G_0 + G_1 y_{t-1} + G_2 y_{t-2} + \cdots + G_p y_{t-p} + e_t$$

where e_t is a white noise process and G_i are the coefficient vectors.

The estimation of the above system is done by OLS for each equation. Usually, the VARs are designed with parsimony in mind as they require large data sets to estimate the coefficients. In this view, the fiscal reaction function is suitable since we do not overparameterize the model. If we rewrite the above equation by using lag operators;

$$(I_n - G_1L - G_2L^2 - \cdots - G_pL^p)y_t = G_0 + e_t$$
$$G(L)y_t = G_0 + e_t$$

If the VAR is stationary, $G(L)$ must be invertible and all polynomial characteristic roots of the determinant of $G(L)$ need to be within the unit circle. If the VAR is not stationary, the impulse-response analysis will not be valid.

According to Bohn (1998), while formulating the fiscal reaction function, the explanatory variables other than lagged public debt need to be endogenously included in the model to avoid omitted variable bias. For this reason, in this study the output gap is included as an endogenous variable in the VAR estimation of the fiscal reaction function.

3.2.2 State Space Model

In the econometric literature, there are several ways of estimating time-varying parameters. Among these models, the state-space model appears to be a very flexible and useful technique for modelling time-varying coefficient models. The state-space model's fundamental intuition is that the impelling force behind the time series data's evolution is unobservable or unquantifiable. Technological and human capital developments, for instance, affect the economy as a whole, but they are barely measurable. Vector Auto Regression models can also incorporate exogenous factors into the model, but those exogenous factors need to be quantifiable for the VAR setting. In this sense, the state-space model outperforms the VAR models by incorporating the hidden elements into the model. The state-space representation allows the estimation of varying parameters in statistical models for each period of time.

Formally, a state-space model of a Y_t the procedure can be modelled as follows[2].

[2] For detailed information about State-Space estimation and Kalman filtering see Harvey (1993) or Neusser (2016)

$X_t \in R^v, Y_t \in R^w, \{F_t\}$ are $v \times v$ matrices
$G_t\ is\ w \times v\ matrix$ and $\{V_t\}$ and $\{W_t\}$ are random disturbances.
$Y_t = G_t X_t + W_t$
$X_{t+1} = F_t X_t + V_t$

The above model represents a W dimensional state-space model with unobserved components. Y_t is the observed dependent variable which is linearly a function of unobservable hidden variable space of X_t. The X_t is also called the state vector in the literature. The Y_t observations are linear conversions of unobserved hidden X_t space. The first equation above is called the signal equation, and the second equation is called the state equation. The mean of the error processes is zero, but the covariance matrices can be dependent on the T, which allows modelling contemporaneous dependence.

$$E[V_t] = E[W_t] = 0$$

$$E[V_t V_t^T] = Q_t\ , E_t[W_t W_t^T] = R_t\ , E[V_t W_t^T] = 0$$

Thus, Y_t is the combination of a transition effect and a white noise process. Practically, the linear transition matrices are assumed to be independent of time. Like other models such as OLS or Vector Auto Regression, the state-space model intends to find the best linear estimators. However, this method is interested in the estimation of the state variables given the set of data until the most contemporaneous value. In other words, this model aims to construct the estimators for the unobserved signal, namely X_t, provided that the observable Y_t is available. Put differently, it attempts to find the best linear estimators of X_t in terms of $Y_1, Y_2, Y_3, , , , , Y_s$ and a random value Y_0 which is mainly set to equal to one. Formally,

$$P_s X_t = A_0 Y_0 + A_1 Y_1 + \cdots + A_s Y_s \qquad A_0, \dots\dots, A_s \text{ is a } v \times w \text{ matrix.}$$

The above equation implies that the model estimates the expectation of X_t given the observable time series Y_t. As the main aim of this technique is to reach a linear predictor provided the real observations of Y_t, the linear combination of X_t in terms of Y_t for the entire sample is generated. These estimations are carried out by means of a Kalman filter. This filter is comprised of predictive and updating equations. The predictive equations constitute the variance and the expected value of the state vector given the observations up to period $t-1$, while the update equation (i.e. filter) reveals the expected value and the variance of state vector given the observations until time t. Besides, the time-invariant coefficients in the model are estimated via maximum likelihood.

In order to benefit from the time-varying performance of the state space estimation, the fiscal reaction function needs to be transformed into a state-space representation. Following the argument of Burger et al. (2012), the fiscal reaction function is transformed into the state space form by assuming a random walk procedure for β_3. According to them, the reason for structuring the time-varying β_3 as a random walk is that as Rapach and Weber (2004) also indicates, the real interest rates in many countries are nonstationary and β_3 is a function of real interest rate since the debt stabilising primary balance was $pb_t = \left(\frac{r-g}{1+g}\right) d_{t-1}$.

Besides, according to many authors, including Burger et al. (2012) and Nguyen et al. (2016), the magnitude of the β_3, the parameter indicating the authorities' effort to stabilise debt, hinges on the $(r-g)/(1+g)$ ratio in the debt evolution dynamics. Therefore, since the real interest rate has been proven to be mostly nonstationary in the literature, and since the β_3 depends on $(r-g)/(1+g)$, β_3 can be assumed to random walk as well.

To complete the transformation, the fiscal reaction function itself becomes the signal equation in the state space setting and the β_3 becomes the state process.

Formally, the fiscal reaction function can be transformed into a state-space setting as follows;

$$pb_t = \beta_1 + \beta_2 pb_{t-1} + \beta_3 d_{t-1} + \beta_4 \hat{y}_{t-1} + \varepsilon_t$$
$$\beta_{3t} = \beta_{3(t-1)} + \eta_t \,, \;\; \eta_t \sim N(0, \sigma_\eta^2)$$

All of the coefficients are set as constant parameters, and only the β_3 is allowed to vary in its random walk form over time.

3.3 Empirical Findings and Discussion

Now that the salient features of the data set and estimation techniques are summarized, in this section of the chapter, the estimation results are discussed to gauge the degree of sustainability of public debt in Turkey. The discussion starts with the formal and informal inspection of stationarity. In the second subsection, the estimation results retrieved from alternative models and techniques are evaluated. Combining all the information revealed so far, the sustainability of public debt in Turkey is elaborated at the end of the chapter.

3.3.1 Stationarity Analyses

Despite the ongoing disputes among scholars, including Bohn (1998)'s aforementioned criticism about too much reliance on the stationarity, the stationarity of the public debt and primary balance series is quite important for the debt sustainability analysis. Besides, the econometric analysis on the next part, to a large extent, requires data to be stationary. Thus, this section explores the stationarity in the data.

3.3.1.1 Visual Inspection

Before interpreting the stationarity by means of formal stationarity test results, some inferences can be made through visual inspection. The data plots and the correlograms can be used for this purpose. By observing the data series plots above, it can be concluded that throughout the sample, the primary balance oscillates within (-4, 4) per cent band for a large part of the range, excluding some outliers. Also, the frequency of oscillation is virtually the same for the data range. Therefore, on the whole, from the very first impression of the data, we can observe a piece of clear visual evidence for stationarity for the primary balance. A similar line of reasoning can be conducted for the debt/GDP series. As it is evident in the data plot, excluding 2001, the debt/GDP ratio fluctuates within (20,50) per cent band for most of the data range. Additionally, the dispersion turns back to its original shape in the post-outlier sections, which is a good sign of mean reversion and stationarity.

The correlograms below also contribute to the visual inspection of the stationarity. On the graphs below, the ACF of both series exhibits geometric decay, which indicates that shocks to the series are not permanent but temporary. Consequently, the series become mean reverting as shocks die out gradually. Also, the ACF for the rest of the lags oscillates within the confidence interval, which is also a good indicator of mean reversion. Additionally, the PACF of both series on the graphs falls abruptly after the first lag, which can also be interpreted as a stationarity sign. This trend indicates that the shocks to a variable do not disperse over other lags and die out, which can be interpreted as a signal for stationarity.

Figure 18 Correlogram of Primary Balance

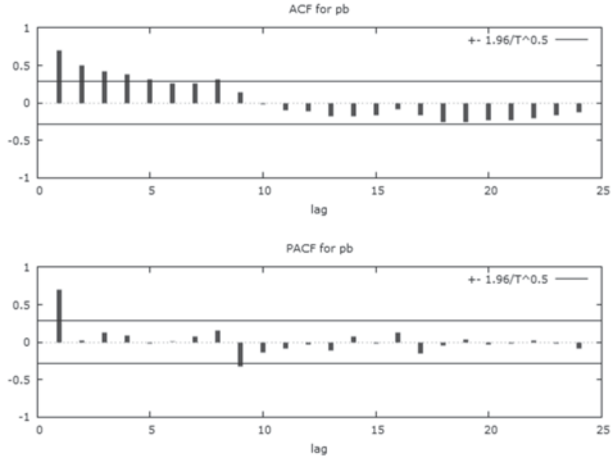
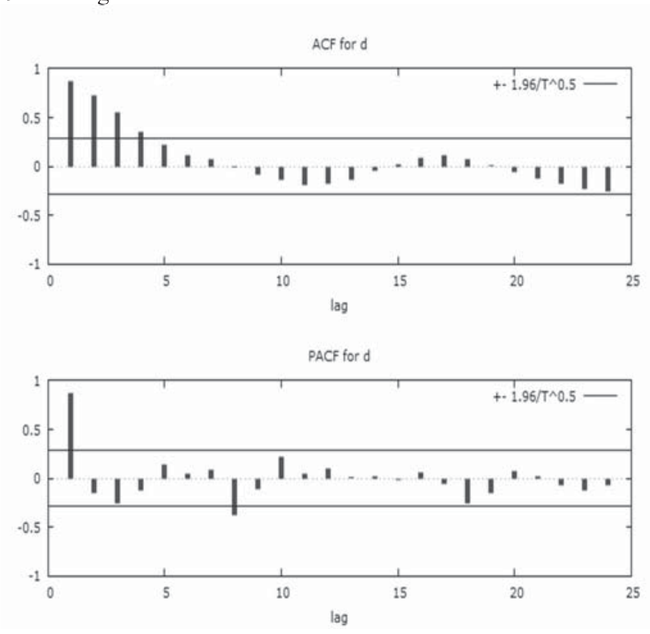


Figure 19 Correlogram of Public Debt



3.3.1.2 Formal Stationarity Test Results

The table below summarizes the test statistics of formal tests for our data set and the critical values for different confidence levels. According to the results below, the ADF test rejects the null hypothesis of a unit root for primary balance at the 10 % level. The PP test rejects the same hypothesis at all levels. Besides, the KPSS test cannot reject the stationarity hypothesis at the 1 %, and the 5 % levels and the DFGLS test reject the unit root hypothesis at all levels, but the ERS test only rejects at the 1 % level. Thus, all the formal tests above conclude that primary balance is stationary.

Table 2 Formal Stationarity Test Results

	ADF	PP	KPSS	DFGLS	ERS
Primary Balance	-2,784273	-2.790986	0.392701	-2.816357	2.025719
1%	-3.577723	-2.615093	0.739000	-2.615093	1.870000
5%	-2.925169	-1.947975	0.463000	-1.947975	2.970000
10%	-2.600658	-1.612408	0.347000	-1.612408	3.910000
Public Debt	-1.706648	-2.036353	0.345765	-1.715220	4.475218
1%	-3.577723	-3.577723	0.739000	-2.615093	1.870000
5%	-2.925169	-2.925169	0.463000	-1.947975	2.970000
10%	-2.600658	-2.600658	0.347000	-1.612408	3.910000
Output Gap	-5.756801	-8.088135	0.136765	-0.704762	2.250483
1%	-3.588509	-3.577723	0.739000	-2.624057	1.870000
5%	-2.929734	-2.925169	0.463000	-1.949319	2.970000
10%	-2.603064	-2.600658	0.347000	-1.611711	3.910000

For the public debt series, however, the formal tests reveal mixed results. ADF and PP tests cannot reject the unit root, whereas the KPSS test cannot reject the hypothesis of stationarity for any levels. DFGLS rejects the null hypothesis of a unit root at the 1 % and 5 % levels, while the ERS test rejects the null hypothesis of a unit root at every level. Hence, for the debt/GDP series, 3 out of 5 tests reveal results favouring stationarity. Also, the visual inspection in the previous section exhibited parallel results. Thus, it is safe to conclude that public debt is stationary too. For the output gap, ADF, PP and KPSS tests reveal results that indicate stationarity, whereas the other two tests show non-stationarity. Therefore, it is also safe to conclude that the output gap is stationary as well. The final point to note here is that the formal stationarity tests are prone to be affected by the sample size, as mentioned earlier in the text. Thus, as in many other articles, it is acceptable to see mixed results for the stationarity of the series.

3.3.2 Estimation Results

3.3.2.1 OLS Estimation Results

Just as Burger et al. (2012) and Bohn (1998) do in their paper, the analysis starts with an OLS estimation of the above equation, assuming a constant parameter for the entire sample. As all the variables are I (0), the coefficients estimated by OLS are reliable and also, the Newey-West method was applied to obtain heteroskedasticity and autocorrelation corrected **(**HAC**)** standard errors.

The equation borrowed from Burger et al. (2012) was;

$$pb_t = \beta_1 + \beta_2 pb_{t-1} + \beta_3 d_{t-1} + \beta_4 \hat{y}_{t-1} + \varepsilon_t$$

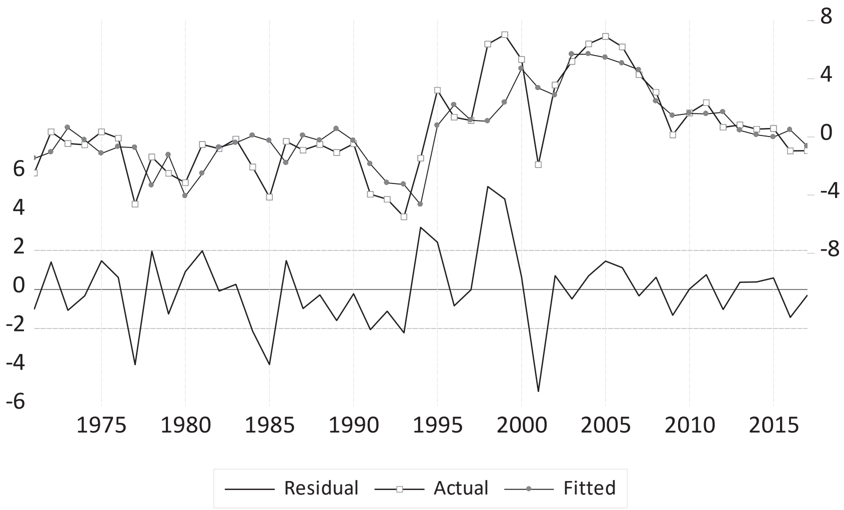
The OLS estimation of the equation reveals the following results with corresponding t statistics in parentheses;

$$pb_t = -2.098 + 0.619 pb_{t-1} + 0.059 d_{t-1} - 0.068 \hat{y}_{t-1} + \varepsilon_t$$

(-2.18) (5.28) (2.62) (-3.001)

Adjusted $R^2 = 0.60$

Figure 20 Actual vs. Fitted Primary Balance (OLS)



The figure above illustrates how well the OLS estimation fits the data. Despite its overall acceptable fit, there are severe disparities between the real primary balance and the fitted primary balance, especially in the 90s. and 80s. Also, partially in the 2000s, the model fails to estimate the indicator properly, evidenced by residuals being out of the confidence band for several years in a row. Not surprisingly, the adjusted R-squared is only 0.60 for this estimation, which corresponds to a low level of the model's explanatory power.

Besides, many authors, including Bohn (1998), concur that constant coefficient models do not cover the fiscal reaction function theory's fundamental notion since the government's fiscal reactions are inherently time-varying. In other words, assuming a constant parameter of 0.059 for the entire sample is too stringent and not realistic. Even though according to Bohn (1998), a positive fiscal reaction parameter is sufficient for a mean-reverting debt profile, in reality, preserving the same amount of positive reactivity in the short run is virtually impossible for any economy. In his subsequent papers, such as Bohn (2007), he also concurs that time-variance property should be incorporated into the coefficient estimation procedure.

However, despite its above-mentioned shortcomings, the OLS estimation results still possess important insights into Turkey's fiscal performance. The first point to make from the results above is that the sign of the β_3 is positive. The positive sign of the coefficient β_3 indicates that the government responds to a rising debt by improving the primary balance, which is a powerful sign of corrective fiscal reaction to establish public debt sustainability, albeit in a narrow sense. Thus, based solely on this coefficient estimation, it can be concluded that, overall, public debt is sustainable.

Apart from the fiscal reaction coefficient, the other coefficients also possess important insights into Turkey's fiscal policy. The positive coefficient of lagged values of primary balance, β_2, for instance, indicates that there is an inertia in the fiscal policy in Turkey. According to that, around 60 % of the government's fiscal behaviour in one year are carried over to the following year. Presumably, this inertia only cuts off when the debt rises by some substantial margin or some impelling forces such as IMF agreements pin down the government to do so.

The positive and large coefficient of the lagged primary balance indicates the government's willingness to largely preserve the fiscal policy stance among consecutive years in a conservative manner. In other words, the government is unwilling to make instant changes in the fiscal policy from year to year and carries over 60 % of the fiscal behaviour in one year into the next period. This tendency indicates the reluctance of the government to transform its chronic fiscal behaviours over time. However, in some cases, this situation might lead to sustainability problems as fiscal reactions might entail swift alterations in fiscal policy under certain conditions. Apparently, apart from the IMF's compulsory transformations, the government lacks fiscal manoeuvrability when needed.

Furthermore, the negative coefficient of the output gap indicates a procyclical fiscal policy by the government. In other words, during the recession, the government cuts spending and hikes taxes, whereas the government increases spending and reduces taxes during recovery. This can be explained by the politico-economic preferences of the authorities. The negative coefficient proves that the government does not systematically respond to output fluctuations by means of fiscal policy tools. Instead, the government makes use of automatic stabilizers to restore the welfare loss in the economy during recessions.

According to Alesina et al. (2008), this type of procyclical fiscal policy is common in developing countries. During dire periods, the developing countries cannot borrow a sufficient amount of funds or only borrow at high interest rates. Hence, they cannot have primary deficits for long periods. To avoid costly borrowing during recessions, they need to cut spending and raise taxes. On the other hand, during recovery, they can borrow under better conditions and increase public spending.

According to the authors, the developing countries could instead accumulate reserves during recovery to ensure a smooth transition to avoid borrowing under harsh interest rate conditions. However, the voters do not trust the corrupt government in developing countries, and instead of accumulation, they demand tax cut and more transfer payments during booms which the government could otherwise waste. These economic intuitions explain why we have a negative coefficient for the output gap in the above equation.

3.3.2.2 Vector Auto Regression Model Estimation Results

In this part, a VAR model with one lag with the same variables is set up to run an impulse response analysis along with the block exogeneity test to evaluate the validity of the fiscal reaction theory for Turkey and thereby enhance the argument regarding public debt sustainability. According to Bohn (1998), the explanatory variables in the fiscal reaction function other than the debt/GDP ratio are influential in the formulation of the function to secure mean reversion in public debt.

According to him, the explanatory variables need to be appropriately formulated. Otherwise, the model will suffer from omitted variable bias. According to calculations using the data set introduced above, the estimation results imply omitted variable bias when the output gap is considered an exogenous variable. This bias brought about misspecifications in the model. For this reason, in the VAR setting of fiscal reaction function, the output gap is included as an endogenous variable which supports the argument in Bohn (1998). However, despite including the output gap in the model, this section's primary concern is still to test the direction of causality between primary balance and public debt.

VAR Estimation Results

The results obtained from the VAR estimation are as follows[3]:

$$pb_t = -2.098 + 0.619pb_{t-1} + 0.059d_{t-1} - 0.068\hat{y}_{t-1} + \varepsilon_t$$
(-1.92) (5.37) (2.07) (-2.24)

$$d_t = 3.195 + 0.088pb_{t-1} + 0.911d_{t-1} + 0.211\hat{y}_{t-1} + \varepsilon_t$$
(0.9852) (0.2570) (10.645) (2.3220)

$$\hat{y}_t = 10.2936 + 1.105pb_{t-1} - 0.310d_{t-1} - 0.109\hat{y}_{t-1} + \varepsilon_t$$
(2.042) (2.075) (-2.334) (-0.775)

In the second equation, the coefficient of lagged primary balance is statistically insignificant, which is in line with the fiscal reaction function's validity since it implies that the public debt is not a function of primary balance. The coefficients are also statistically significant in the first equation, which is also suggestive that the fiscal reaction function is valid for Turkey, given the data set used.

Impulse-Response Analyses

Since our primary research area is the government's fiscal response to debt dynamics, the impulse-response analysis can provide additional evidence on the (non)existence of such a response. Also, along with the reaction of the primary balance of the public debt, the analysis can be extended to include the primary balance response to shocks on other variables in the model. The output gap and lagged primary balance are also internal parts of

[3] See appendix for VAR inverse roots and residual tests results for the stability of VAR and OLS.

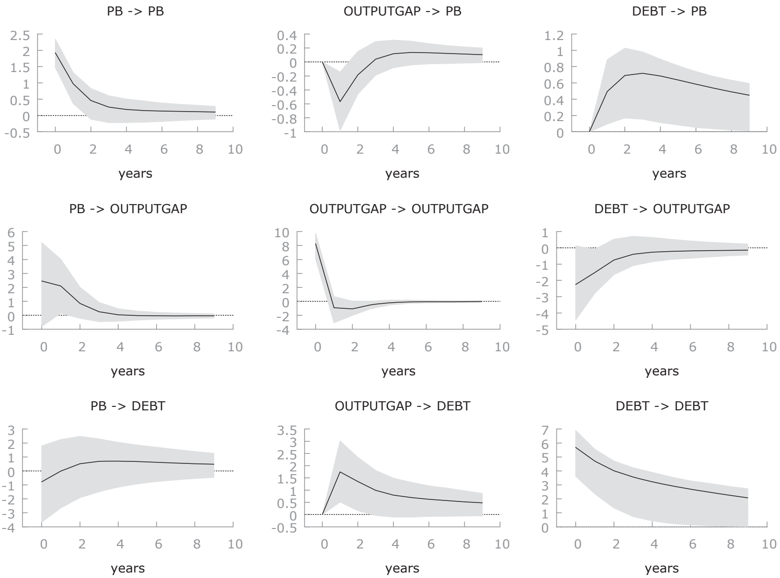
the fiscal reaction function; therefore, the primary balance response to those variables is also an integral component of our analysis.

Figure 21 below plots the impulse-response graphs altogether. The stationarity of the variables is also evidenced by the graphs below as the auto-responses of each variable fade out gradually and are not permanent. Moreover, the first graph in the first row shows that the aforementioned inertia in the primary balance shrinks after the second period and fades out gradually. Apparently, when designing the budget, the government conveys the part of the fiscal action in the previous year but not that of the former years. The government, to a large extent, tends to be conservative in amending the fiscal policy. Besides, the second graph in the first row clearly illustrates the procyclical behaviour of the fiscal policy, which was also indicated by the former econometric analyses above.

As Alesina (2008) points out, the government is unable to borrow under good conditions during recessions. That's why it needs to cut spending and/or raise taxes to avoid borrowing under harsh conditions such as short maturity or high interest rates. However, our primary focus is obviously the response of the primary balance to a shock in public debt, which is depicted on the third graph in the first row. As it is clear from the illustration, the primary balance positively responds to a rise in public debt. In other words, if the debt rises, the government responds by improving the primary balance. This finding is in line with the fiscal reaction theory and implies sustainability in the public debt from a narrow perspective.

Nevertheless, reversing the direction of shock changes the results substantially. In other words, a shock on the primary balance does not have a profound impact on the other variables, as evidenced by the second and third graphs on the first column. By virtue of this fact, it can be stated that the impulse response analysis contributes to the validity of the Burger et al. (2012) formulation of the fiscal reaction function for Turkey. For this reason, it can be noted that the VAR analysis supports the validity of the formulation of the fiscal reaction function. Still, at the same time, the empirical findings point out the limitations of the constant-coefficient models. If we consider the existence of a positive effort as an indicator of public debt sustainability, the final decision should be made with some reservation in mind taking the shortcomings of the constant parameter model estimations into account.

Figure 21 Impulse-Responses



Block Exogeneity Wald Test

The final analysis in the time-invariant section is the causality test to verify the validity of the fiscal reaction function. The term causality refers to the cause-and-effect relationship between two variables. The logic behind the exogeneity test is that if a variable is said to cause another variable when it gives rise to more accurate modelling of the other variable compared to univariate analysis. In other words, the causing variable cannot be excluded from the model explaining the variations in the other variable. In the literature, this test is also known as the Granger causality test. Suppose one variable Granger causes the other variable. In that case, the latter can be estimated more appropriately by using the history of both variables rather than using the history of the former alone. The existence of a Granger causality between variables shows that one variable aids in predicting the other variable. Hence, this test can reveal evidence regarding the validity of the way the fiscal reaction function is formulated. In other words, the direction of the causality provides the ground for the suitability of the formulation of the fiscal reaction function for Turkey. According to Bohn (1998), public debt is sustainable if it moves due to the government's fiscal responses. Hence, if the test results imply that the primary balance can be modelled more properly by employing the history of public debt instead of univariate analysis, (i.e. public debt Granger causes primary balance), then the validity of the fiscal reaction function theory is proven. Depending on the estimation results, the causality can also be considered as an indicator of sustainability.

The results of this test are depicted in Table 3 below. The main research in this study focuses on the nexus between public debt and primary balance. According to the fiscal reaction theory, the primary balance has to respond to movements in the public debt to guarantee sustainability in the public debt. The test results of the equation where the primary balance is the dependent variable below suggest that primary balance indeed responds to public debt movements. In other words, the exogeneity test below is in line with the VAR estimation results above. The public debt cannot be excluded from the equation estimating the primary balance. Also, the output gap needs to appear in the equation modelling the primary balance as well, which is in line with the arguments of Bohn (1998).

However, the second equation's test results imply that primary balance can be excluded from the equation where the public debt is the dependent variable which is also suggestive of the soundness of the fiscal reaction theory. In other words, the findings imply that the primary balance is responding to the public debt movements but not the other way around. For this reason, it can be stated that there is sufficient evidence for the validity of the formulation of fiscal reaction function theory based on Turkish data.

This finding of the test reinforces the estimation results and adds to the conclusion that there is a systematic response of primary balances to the public debt in Turkey. This is a good indicator of public debt sustainability as the movements in the public debt can be at least partially attributed to primary balance realizations. In other words, any model which aims to estimate the primary balance as a dependent variable should include the public debt series as an independent variable for achieving more accurate results, which is an apparent decomposition in the way Bohn (1998) describes. The last two tests also indicate that at the 1 % level, the independent variables of the public debt and output gap equations can jointly be excluded from the model, which again reinforces the fiscal reaction argument for Turkey.

Table 3 Block Exogeneity Wald Test

Dependent Variable: PB			
Excluded	Chi-Sq	df	Prob.
DEBT	4.31	1	0.0378
OGAP	5.05	1	0.0246
All	15.49	2	0.0004

Dependent Variable: DEBT			
Excluded	Chi-Sq	df	Prob.
PB	0.06	1	0.7972
OGAP	5.38	1	0.0203
All	6.68	2	0.0353

Dependent Variable: OGAP			
Excluded	Chi-Sq	df	Prob.
DEBT	5.44	1	0.0196
PB	4.30	1	0.0380
All	6.26	2	0.0436

3.3.2.3 Time-Varying State Space Model Estimation Results

The time-invariant coefficient model estimations in the former section suggest that public debt is sustainable in Turkey. However, this conclusion is valid in a narrow perspective and satisfies only the weak requirements for debt sustainability. According to Bohn (2008), for the broader analysis of public debt sustainability with more robust requirements, time-varying properties should be incorporated into the framework. The fiscal reaction parameter needs to be positive for a larger portion of the data set. Nevertheless, the constant coefficient models lack the feature of portraying the evolution of inherently varying fiscal reaction indicator. Besides, a constant coefficient of the entire sample indicates that the government performs the same level of fiscal reaction each year, which is highly unrealistic. Thus, in this section, the fiscal reaction function is estimated in a time-varying formation through the state-space model to incorporate the evolution of fiscal reaction parameter to the analysis.

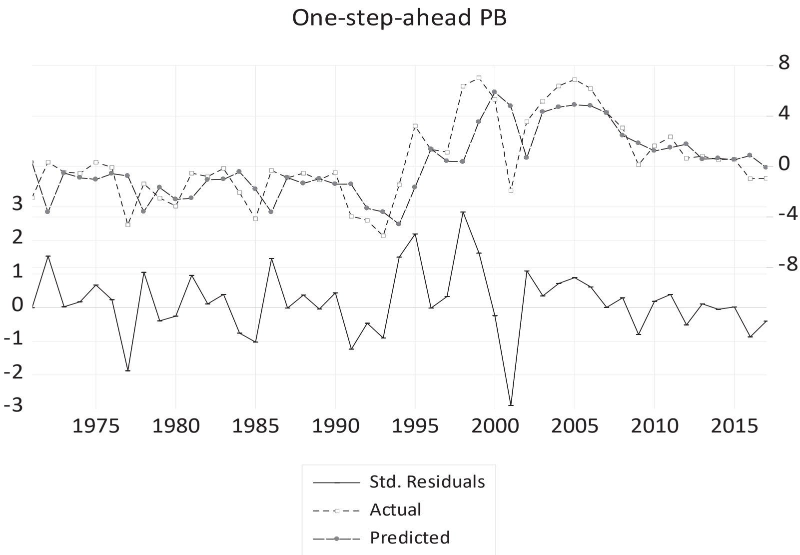
Following the procedure described in Burger et al. (2012), the fiscal reaction function is transformed into a state-space representation with one time-varying parameter, which is obviously the fiscal reaction parameter of the public debt, namely the β_3. All other variables are assumed to be time-invariant and β_3 is specified as a random walk. In this case, the fiscal reaction function becomes the signal equation and the β_3 becomes the state process. Just as Burger et al. (2012) do, the constant term is omitted as it was statistically insignificant.

Formally;

$$pb_t = \beta_2 pb_{t-1} + \beta_3 d_{t-1} + \beta_4 \hat{y}_{t-1} + \varepsilon_t$$
$$\beta_{3t} = \beta_{3(t-1)} + \eta_t\ ,\ \ \eta_t\ \sim N(0, \sigma_\eta^2)$$

The figure below illustrates the one step ahead standardised residual, actual primary balance and fitted values of the state space model estimation. It is clear from the figure that, with the exceptions of the petroleum crisis in the 70s and the financial crises of 1994, 1998 and 2001, the residuals are well behaved and noticeably stationary.

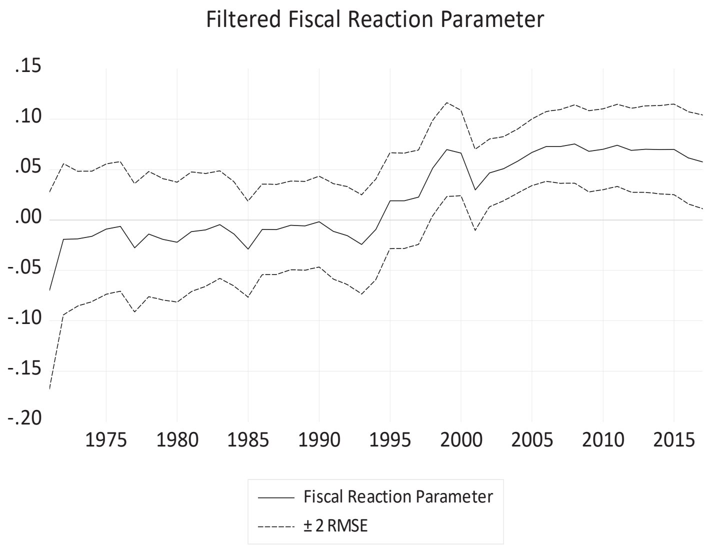
Figure 22 Actual Fitted Residual (State Space)



Compared to the OLS estimation, the state space version of the fiscal reaction function estimates the model more accurately and generates a better fit to the actual data. Also, the residuals in the state space setting oscillate in a narrower band compared to the OLS. The state-space model outperforms the OLS model during the crisis periods as well since the gap between the actual and fitted lines is narrower in the former than in the latter. This finding also contributes to the idea that the fiscal reaction function can more properly be estimated in a time-varying setting than in a constant-coefficient setup.

Figure 23 below depicts the point estimations of time-varying fiscal reaction coefficients in a confidence band covering two RMSEs. The filtered estimates of the reaction parameter imply that the fiscal reaction to debt dynamics is far from being constant over time. The time variation in the evolution of fiscal reaction is quite remarkable during the estimation period. Put differently, the government's fiscal reaction strength is not constant but varies over time and largely influenced by external conditions. The first impression of the figure implies that the Bohn (2008) criterion for debt sustainability is not satisfied in Turkey when the position of the confidence band is considered for decision making. In particular, the slightly larger portion of the reaction parameter band is in the negative zone, indicating unsustainability in Turkey's public finances even though the positive portion is not far off. However, the confidence band is never entirely below zero. It is almost always entirely above zero after the late 90s, which can be interpreted as an indicator for sustainability in a manner described in Greiner et al. (2007).

Figure 23 Evolution of Fiscal Reaction Parameter



The evolution of the parameter in Figure 23 above exhibits a clear time-variation. Still, this variation is not random but is in harmony with the country's recent macroeconomic history. As argued in the previous sections, the 1970-2000 part of Turkey's recent economic history is shaped by several economic challenges such as international crises, funding shortages, inflation, etc. The evolution of the parameter reflects these economic conditions over time. The fiscal reaction coefficient is consistently below zero for almost every year until the late 90s, indicating the absence of fiscal reciprocation strength. Negative levels of fiscal reaction in this period are also suggestive that the debt/GDP ratio was not under the government's direct control. In other words, the movements in this ratio were the outcomes of market conditions instead of government fiscal policies, which is obviously not a favourable situation as far as the sustainability of the public debt is concerned. Apparently, no policies implemented during the 70s were sufficient for bringing about an upward movement in the reaction parameter to move it to positive territory. The liberal transformation in the 80s appears to have a positive impact on the reaction parameter, but this upward trend lasts only until the mid-80s and disappears before the parameter reaches the positive zone.

Until the mid-90s, the point estimation of the fiscal reaction parameter remained persistently below zero, which is a clear violation of the fundamental requirements for public debt sustainability from Bohn (1998) and Bohn (2008) perspectives. Put differently. The fiscal policies were in a way muted during this period, even though there was an upward movement in debt/GDP ratio until the 90s, which requires a positive reaction to keep the debt dynamics under control. Since no such positive reactivity existed in the fiscal policy, the debt/GDP ratio kept mounting continuously during the mid-80s and late 90s. Also, the real interest rate was positive, and the growth level was low during this period. In the absence of a positive fiscal reaction, these factors dramatically increased the public debt/GDP ratio through the snowball effect. In the second half of the decade, the reaction parameter's point estimation arrived at the positive region. The real interest rate started falling, which gave rise to a partial decline in the public debt ratio. Apparently, in an attempt to gain control over public debt dynamics, Turkey has largely transformed its fiscal reaction policy in the mid-90s. spurred by the IMF agreements.

In the figure above, the evolution of the fiscal reaction parameter clearly points to this transition. Until 1995, the fiscal reaction parameter appears to oscillate in the sub-zero sector, which is an indicator of insufficient fiscal reaction leading to a potentially unsustainable debt position. The upward trend starting in 1994, on the other hand, is indicative of heightened efforts of the government to stabilise the public debt. In other words, until the late 90s, the government has failed to systematically respond to debt fluctuations to design the external economic conditions. It is clear that the government pursued an active reaction policy following the IMF agreement in the late 90s, which impelled the government to control the public debt dynamics since no such reaction power existed until the late 90s, according to estimation results from time-varying setting.

In chapter two, it was proposed that the reaction coefficient needs to be positive for the public debt to be sustainable in a weak sense. However, according to point estimations of the fiscal reaction parameter, this condition is only met in the post-1995 section of the sample. In other words, contrary to the constant parameter model estimation results, a positive reaction parameter did not exist in the economy for the entire sample. At this point, an interesting argument is worth noting from the parameter oscillation standpoint. Before the second half of the 90s, a considerably large portion of the band is below zero. In contrast, after the late 90s, the situation is just the opposite. The transition to positivity is visible, such that the point estimations and the entire confidence band are above the zero level. Excluding the trivial deviation in the 2001 crisis year, the partitioning between the two sub-periods indicates an evident transformation in Turkey's fiscal policy over time. Under the IMF agreements' supervision, the governments performed strong adherence to fiscal discipline, especially in the early 2000s, which generated sufficient fiscal reaction capacity to reduce the already accumulated debt stock.

From the late 90s onwards, the reaction parameter is consistently above zero. It appears to be stabilised around the 0.05 level. Still, unlike OLS results, this result indicates that this value is obtained as an outcome of a series of fiscal policy alterations and did not constantly appear in the entire sample. This situation suggests that the government has gained the fiscal power needed to react to unpleasant public debt realizations, but the fiscal policy has not been that powerful throughout the entire sample. As can be seen on the graph, before the 90s, the reaction parameter is far below this level which clearly points out the shortcomings of the constant parameter models in assessing public debt sustainability. The figure above clearly illustrates that assuming a constant parameter for the entire sample and making judgments about public debt sustainability provides only a narrow perspective for analysis. The OLS value can be a good approximation for some sectors of the data set, but the reaction parameter was definitely not the same throughout the sample range. Put differently, the time-varying estimation of the fiscal reaction parameter provides more insightful and meaningful arguments as far as public debt sustainability is concerned.

As an outcome of the fiscal transformation in mid-90s, the primary balance ceased to be a passive outcome of the economy but became a powerful tool in the policy arsenal of the government used for reacting to the fiscal troubles in the economy. Notably, in 1995, the fiscal reaction coefficient goes beyond the zero level for the first time, which is a clear breakpoint in the fiscal strength enlargement process of the late 90s. However, starting with 1998, the parameter exhibits an unprecedented and systemic rise thanks to a strong commitment by the government to the fiscal rules imposed by the IMF programme, albeit with some temporary pauses during the earthquakes and economic crises episodes. This situation is evidenced by the position of the entire confidence band being above the zero line. In other words, the existence of systematic and positive fiscal reaction is evidenced by the location of the confidence interval, which is located in the positive territory as a whole.

The fiscal transformation seen on the graph is indeed a radical improvement in the parameter and, not surprisingly, corresponds to the point where the debt/GDP ratio starts falling. Nevertheless, the upward trend in the parameter halts through the end of the estimation period and starts to decline, which can be interpreted as an early warning signal for the recently deteriorating conditions in debt management.

3.3.2.5 Snowball Effect and Fiscal Reaction

The algebraic formulations and graphical illustrations in the first chapter proved that there are two major forces impelling the movements in the public debt over time. Equations 7 and 9 in the first chapter summarizes these opposing forces formally.

$$d_t = \frac{(1+r_t)}{(1+g_t)} d_{t-1} - pb_t \qquad (7)$$

$$\Delta d_t = (\phi_t - 1) d_{t-1} - pb_t \qquad (9)$$

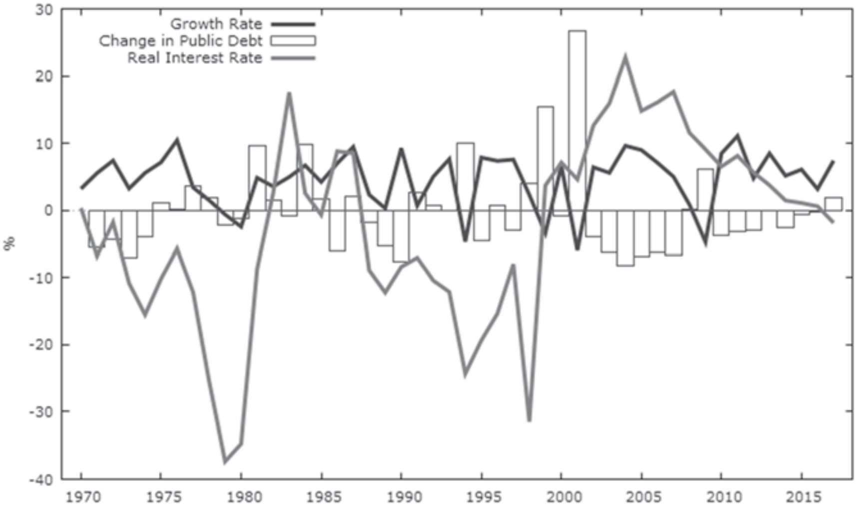
The ϕ_t (or $\frac{(r_t-g_t)}{(1+g_t)}$) in the above equation represents the snowball effect while the pb_t denotes the fiscal reaction strength of the government. Algebraically, the real interest rate and the growth differential (the snowball effect) have accelerating effects on the public debt. In contrast, the positive fiscal reaction potentially decelerates the public debt once appropriately exercised by the government. Hence, the movements in the public debt are to a large extent determined by the interaction of these two opposing forces. For this reason, it is worthwhile to enhance the argument by incorporating the impact of the snowball effect into the analysis. However, unlike developed countries, there are long periods of negative real interest rates and negative growth in developing countries. In other words, even though, in theory, the real interest rate and growth are generally positive, in developing countries, there can be long sequences of negative growth rate and negative real interest rate combinations (Burger et al., 2012). In this case, in contrast to the fiscal reaction theory's postulations, the real interest rate-growth differential does not have a positive snowball effect on public debt. Instead, they work in the opposite direction and might reduce the debt/GDP ratio depending on the magnitude of the growth rate and the interest rate differential.

Unlike the snowball effect, the fiscal reaction does not appear automatically since it is discretionary for the government. In other words, the fiscal reaction is not a systematic process, but a contingent policy choice whose existence hinges on several factors. This property of the fiscal reaction is also evidenced by the time-varying estimation which is illustrated in Figure 23 above. As argued above, the reaction parameter is not constant, and there is an inherent time-variance in the fiscal reaction parameter. It reaches positive values only after harsh policy amendments. However, despite the differences in their characteristics, these two forces jointly determine the direction in which the debt/GDP ratio will move in the next periods.

From the fiscal reaction function standpoint, such a decomposition is quite insightful for testing the extent to which the public debt dynamics are under the direct control of the government's fiscal policies. As it is clear from the theoretical discussions in the first chapter, the positive snowball effect ($r_t > g_t$) increases public debt automatically, but a contemporaneous positive fiscal reaction trims the opposing effect of the positive snowball effect. A negative snowball effect, on the other hand, exists when $\frac{(r_t - g_t)}{(1+g_t)} < 0$ which can occur when both the real interest rate and the growth rates are negative or when the growth rate is positive but has an absolute value higher than the real interest rate. The negative snowball effect can also exist in the case of a positive real interest rate and a positive and significant growth rate. However, the ultimate impact of the negative snowball effect on the debt dynamics hinges on the underlying conditions giving rise to it. Both conditions might seem favourable for the debt dynamics in the short run. Still, the first case, where the real interest is negative, and the growth rate is shallow, might have deteriorating effects on fiscal management and overall economic performance. Since the real interest rate is negative, the government cannot roll over the existing debt or can only service it in shorter maturities since negative real interest rates will be a disincentive for the new investors. Based on the fiscal reaction theory, clearly, the most appropriate case for a country is when the real interest rate and growth are greater than zero, and there is a positive fiscal reaction to keep the impairing effects of the positive snowball effect under control. According to the estimation results, this type of favourable economic environment existed in the economy only after the IMF agreement went into effect in 2002. Kapapuolas and Lazaretou (2012) also approve that the real interest rate and growth were suitable for debt reduction in Turkey during this period.

Figure 24 below illustrates the snowball effect $(r_t - g_t)$ and the periodic change in the debt/GDP together.

Figure 24 Snowball Effect and Change in Public Debt



The figure above indicates that in the early 2000s, the real interest rate remains steadily positive, which was one of the IMF stabilisation programmes' tenets to attract international investors for financing the country. Combined with the positive growth rate in the early 2000s, a positive, albeit declining, snowball effect appeared in the economy. Besides, as illustrated in Figure 23, the fiscal reaction coefficient was also positive during this period. Apparently, it was large enough to offset the deteriorating effects of positive real interest rate and growth differential, which is evidenced by consecutive falls in the public debt in Figure 24. In this period, the debt/GDP ratio declines continuously, which means that the positive primary balance reaction during this period was so powerful (in Figure 23) that despite the deteriorating effects of positive $r_t - g_t$ levels, the debt/GDP ratio halved from 80% to 40% in just a few years. In other words, the fiscal reaction of the government was large enough to eliminate the debt accumulating effects of positive interest rate growth differential. Also, it provided the government with the fiscal space needed to reduce the existing debt level.

Nevertheless, right before the 2001 economic crisis, the change in debt/GDP ratio appears to be zero, indicating that the fiscal reaction's corrective impact has been just equal to the snowball effect. However, during the crisis, the debt/GDP ratio climbs abruptly and tops out with a record high level, which is largely due to the rapid fall in growth rate and the insufficient fiscal reaction. Even though the reaction parameter was still positive during this period, it was far from offsetting the impairing effects of a lower growth rate. Clearly, a much larger fiscal reaction was needed to avoid the rise in the debt/GDP ratio in this period. It can be noted in Figure 23 that the upward trend in the fiscal reaction parameter pauses during the 2001 crisis and is restored after the crisis as an outcome of the renewed agreements with the IMF.

Until the global crisis in 2008, the economic conditions appear to be favourable from a debt dynamics perspective. A positive growth rate that reduces the denominator of the ratio; a positive real interest rate that allows for the public debt rollover; a positive fiscal reaction that trims the adverse effects of the positive real interest rate were the remarkable features of this period. However, through the end of the estimation period, these favourable conditions seem to disappear since all three indicators are in a declining trend in the 2010s. The debt/GDP level keeps falling until 2015, but afterwards, the rate of decrease in public debt drops gradually, and finally, there is a positive change in this ratio in 2017. In an economic condition characterized by positive growth and a low or even negative real interest rate (negative snowball effect), the recent deterioration in the debt/GDP ratio can be explained by the declining fiscal reaction shown in Figure 23 above. Hence, assuming that positive growth and low real interest rate conditions will keep existing in the economy, the declining fiscal reactions can be interpreted as a bad signal for the dynamics of debt/GDP in the near future.

Hence, recent economic history can be partitioned into two sub-periods in terms of fiscal management. Until the late 90s, the government was unable to react positively to ongoing debt developments, but after the late 90s, it managed to respond positively to increasing debt, albeit insufficiently during dire periods. One of the remarkable indicators of relatively more profound fiscal policy in the 2000s is how the increase in public debt during the 2008 global recession measures up against the change in the 2001 crisis. Compared to 2001, the increase in public debt was fourfold lower in 2009.

Unlike the economic slump in 2001, the 2009 crisis occurred when $r_t - g_t$ the differential was positive, which could exacerbate the indebtedness even further if the contemporaneous fiscal reaction had not been positive because the fiscal reaction theory implies that a positive $r_t - g_t$ brings about explosiveness and disequilibrium in public debt dynamics since $r_t > g_t$ but the explosiveness can be eliminated even in the case of $r_t > g_t$ when the fiscal reaction is positive and sufficiently large.

Negative levels of $r_t - g_t$, however, are common in developing countries and in the short-run are advantageous for satisfying intertemporal solvency. Nevertheless, intertemporal solvency is not sufficient for sustainability, and besides, there are good and bad ways of being solvent. One of the unpleasant ways of being solvent is the coexistence of the negative snowball effect and negative fiscal reaction coefficient. From 1970 until the late 90s, the $r_t - g_t$ was negative with negative r_t which assisted the government in satisfying the intertemporal solvency. However, the facilitated fulfilment of the intertemporal solvency condition was by no means sustainable since it was based on a perpetual negative snowball effect.

Recently, despite occasional declines, the reaction parameter is still positive in the last five years of the data set. Also, the $r_t - g_t$ differential is following a very convenient trend for public debt sustainability since the growth rate is bigger than the real interest rate while both indicators are positive. This convenient trend in $r_t - g_t$ guarantees non-explosiveness in public debt. In addition to the stable equilibrium arising due to the favourable $r_t - g_t$ environment, the fiscal reaction parameter is still in the positive territory despite being in a gradual decline. Thus, it can be concluded that the two opposing forces of debt dynamics work in favour of public debt sustainability in recent years.

However, there are two alarming issues regarding the recent optimistic fiscal atmosphere in Turkey. Firstly, the real interest rate hits negative levels at the end of the period, which can hinder future borrowings by generating a disincentive for the lenders. Secondly, the fiscal reaction parameter is in a downward trend. Apparently, it will hit negative levels once again in the near future, which is also worrisome for public debt sustainability. Even though according to Bohn (1998), a positive reaction parameter is sufficient for debt sustainability, the declining trajectory raises concerns about the potential debt crisis in the following periods. Whether the country will be able to meet strong sustainability requirements in the future depends on the real interest rate and growth realizations as well as the future course of the fiscal reaction strength of the government. Thus, although it is safe to conclude that the estimation results are indicative of stabilisation in debt/GDP through a policy transformation, sustainability also requires the preservation of the status of stabilised public debt level in the long run. For this reason, to maintain the current status of the debt dynamics, the current falling trend in the reaction parameter should be reversed promptly by proper policy alterations.

CONCLUSION

This book quantified and appraised public debt sustainability using Turkish data in various settings. In order to investigate the level of the sturdiness of the public debt sustainability in Turkey, the fiscal reaction function designed by Burger et al. (2012) was adapted to the Turkish economy. The first reason for borrowing this model is that both South Africa and Turkey are classified as developing countries and have economic histories which are characterized by large volatilities, and also, long sequences of negative interest rates and primary deficits are common in the economic history of both countries. Besides similarities between countries, the convenient form of the transformation within the model is the second reason for using their model for the analysis. In particular, the authors transform the fiscal reaction function into a state-space setting in a practical manner by making sensible derivations to convert the fiscal reaction parameter into a state equation. Hence, the indicated similarities between the South African and Turkish economies and the seemingly practical approach designed by these authors were the grounds for choosing their model. For assessing public debt sustainability in various stringencies, the indicated fiscal reaction function was estimated in a time-invariant setting with constant coefficients and also in a time-varying set up to monitor the evolution of the sustainability over the 1970-2017 period.

The estimations in the time-invariant coefficient setting suggest a positive fiscal reaction in Turkey, which guarantees public debt sustainability. Although assuming a constant parameter for the entire range is seemingly restrictive, according to Bohn (1998), it is sufficient for sustainability, at least in a weak perspective. Another finding obtained within the time-invariant setting is that the primary balance responds positively to a shock in public debt, according to impulse response analysis which is another indicator of sustainability. Besides, block exogeneity test findings imply that the formulation of the fiscal reaction function is valid for Turkey, which backs the arguments about public debt sustainability in Turkey. Overall, these results from the time-invariant setting are indicative of the existence of public debt sustainability in Turkey, albeit in a narrow perspective. However, the time-invariant results provide a restricted room for analysis since they reveal no insight into the evolution of sustainability over time and assumes that sustainability existed for the entire estimation range.

Findings from the time-varying setting, on the other hand, are suggestive of the fact that the fiscal reaction coefficient is not systematically positive for the entire estimation period. Unlike time-invariant estimation results, the time-varying estimation results indicate that the sustainability of the public debt did not exist throughout the entire sample, and it was achieved as an outcome of a fiscal transformation. Also, according to the time-varying estimation results, there is a razor's edge situation between the size of the negative and the positive sectors of fiscal reaction. The slightly larger portion of the reaction parameter series is in the negative territory within the sample. However, the positive section is not far off in terms of partitioning, and the difference is only marginal. Also, throughout the estimation range, the confidence band is never completely below zero. In contrast, it appears in the positive sector during the entire late 90s section of the data. These two initial findings from time-varying estimations can be interpreted as good signals for sustainability, but the final verdict about sustainability hinges on how stringently these findings are evaluated through normative judgements.

According to these findings, the recent economic history of Turkey can be partitioned into two sub-episodes in terms of fiscal management. During the first sub-period, the lack of systematic and positive fiscal response can be observed from the filtered state estimates of the fiscal reaction coefficient from 1970 until the mid-90s. During this period, the reaction coefficient was consistently below zero, indicating the government's unsustainable debt policy for the first 25 years of the estimation sample. In other words, the public debt dynamics were not under the direct control of the government. The movements in the public debt were largely characterized by the snowball effect and external factors that are not sustainable in the long run.

The uncontrolled trajectory of the public debt during the first sub-period was obviously unsustainable, evidenced by the long sequence of negative fiscal reaction parameters. However, after the mid-90s, the fiscal reaction coefficient reaches the positive territory, which points out that the government embarked on a fiscal management program during the second sub-period tailored by the IMF agreements and performed strong adherence to those programmes to stabilise the public debt. Despite some temporary pauses in the upward trend of the positive fiscal reaction because of earthquakes and economic crises, the striking shift in the fiscal policy is evidenced by the time-varying estimation of the fiscal reaction function. As a result of this pronounced transformation, during the 2000s, especially after the 2001 crisis, the fiscal reaction coefficient remains consistently above zero even as a confidence band which explains the halving of the debt/GDP ratio in just a few years after topping out in 2001. This period is characterized by the high performance of the government in terms of debt reduction and fiscal responsiveness. However, the quality of this strong performance is open to discussion since the primary surplus generated during this period was to a large extent based on temporary tax income generation rather than profound structural reforms in overall fiscal policy. Thus, despite the fact that positive fiscal reaction parameters were achieved during this period, the underlying policies were mostly short-sighted and temporary, which reduced the quality of the fiscal transformation.

One of the tenets of the 2002 IMF agreement was a positive real interest rate to provide an incentive for foreign investors. Also, the growth rate was persistently positive during the same period. Typically, the positive real interest rate would worsen the debt position even further, but the impairing effects of the positive real interest rate were trimmed through positive fiscal reactions during this period. As a result, the debt/GDP ratio fell dramatically in a short period of time after 2002. During the post-2008 subsection, however, the joint forces of the snowball effect and the fiscal reaction favour debt management since the real interest rate, growth rate and fiscal reaction parameter are all in positive territory. Also, except for the early 2000s, the growth rate is generally higher than the real interest rate, leading to a negative snowball effect and, consequently, non-explosiveness is secured for the public debt. In other words, the early 2000s were characterized by a deliberate positive snowball effect to attract the influx of foreign capital and a positive fiscal reaction to trim the excessive movements in public debt arising due to the positive snowball effect.

However, there are alarming issues concerning the future of this environment, which is currently convenient for public debt management. The real interest rate, for instance, recently hits negative levels, which have alleviating effects on public debt management in the short run. Still, it has a deteriorating impact on the overall economy by hindering external funding, which is crucial for developing countries. Secondly, the fiscal reaction parameter is in a falling trajectory which is also worrisome for public debt management. Evidently, the fiscal reciprocation strength is gradually waning in recent years and thereby, the country is departing from its prudent approach to public debt sustainability which raises concerns about a future debt crisis. Even though it is still in the positive zone, it is consistently heading towards negativity which is worrisome about the long-run public debt sustainability. If the convenient real interest rate and growth rate environment ceases to exist, potential negativity in the fiscal reaction parameter might lead to explosive public debt in the near future. In other words, persistent negativity in this parameter will leave the government off-guard in the event of a negative shock to snowball effect.

In other words, the second sub-episode of a remarkably high level of fiscal reaction appears to be fading out following the global crisis in 2008 as the reaction coefficient is heading towards negative territory once again after some 20 years of upward movement. The primary balance has been repeatedly in deficit in recent years, which clearly indicates that the government is losing its strength in using the primary balance as a tool to stabilise the public debt. Also, since there is a vicious circle between public debt and perpetual primary deficits, compounding interest payments will eventually be financed by increasing public debt, promoting the likelihood of a potential debt crisis. In other words, the falling trajectory of the fiscal responses conveys the country to an unsustainable debt position. Therefore, the current negative trend in the fiscal reaction parameter should be reversed by improving the primary balance to revert the unfavourable trend to avoid a severe debt crisis reminiscent of 2001.

Public debt sustainability is inherently a forward-looking concept; therefore, preserving the currently stabilised level of the fiscal reaction parameter is as important as achieving it through fiscal transformations like in the early 2000s. Maintaining the current status of this parameter entails a continuum of primary surpluses in the following years to not lose control of the future course of public debt in the country. Even though there are several ways of achieving such an improvement in primary balance, including tax-hiking, reducing profligacy and extravagance by spending cuts so forth, determining the optimal timing and the composition of the fiscal adjustments require in-depth considerations and calculations regarding the social costs (education, health, security etc.) associated with the fiscal adjustments. The calculation of the amount of fiscal adjustments required to revert the fiscal reaction parameter to positivity and their potential social costs is beyond the scope of this book. Still, it is evident that a spending cut with a back-loading adjustment is less painful for the society than a severe tax hike with a front-loading adjustment. Hence, it is more appropriate to prefer the former over the latter from a fiscal management perspective. Also, minimizing the hidden deficits in the public financial accounts and implementing profound performance-oriented structural reforms such as widening the tax base, increasing the portion of direct taxes, restructuring the borrowing policies to reduce the interest payments might potentially facilitate the primary surplus generation in the future. Besides, political pressure on budgeting should be reduced to implement primary balance targeting through budgetary discipline similar to the 2000s.

Finally, one caveat about the estimation results is worth noting at this point. The empirical findings in this work are either tentative or suggestive, but they are by no means decisive. Hence, the empirical results entail interpretations bearing their limitations in mind. Nevertheless, the fiscal reaction function is the most practical method of quantifying debt sustainability, especially for developing countries with data scarcities.

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Appendix

Computer Codes for Calculating the Output Gap with Kalman Filter (For Eviews sspace object)

```
param c(1) 0.9  c(2) 0.2  c(3) -10  c(4) -10  c(5) -10

@ename v1

@ename v2

@ename v3

@evar var(v1) = 0

@evar var(v2) = 0

@evar var(v3) = exp(c(5))

@signal lrgdp_sa = trend + cycle

@state trend = trend(-1) + beta(-1) + v1

@state beta = beta(-1) + v2

@state cycle =c(1)*cycle(-1) + c(2)*sv1(-1) + v3

@state sv1 = cycle(-1)
```

VAR Inverse Roots

VAR Residual Tests

VAR Residual Heteroskedasticity Tests: Includes Cross Terms
Date: 12/02/19 Time: 00:29
Sample: 1970 2017
Included observations: 47

Joint test:

Chi-sq	df	Prob.
71.47968	54	0.0558

Individual components:

Dependent	R-squared	F(9,37)	Prob.	Chi-sq(9)	Prob.
res1*res1	0.180728	0.906893	0.5295	8.494209	0.4852
res2*res2	0.355244	2.265118	0.0390	16.69648	0.0537
res3*res3	0.082570	0.370006	0.9421	3.880795	0.9191
res2*res1	0.263929	1.474101	0.1938	12.40468	0.1914
res3*res1	0.278048	1.583326	0.1565	13.06825	0.1595
res3*res2	0.237598	1.281200	0.2796	11.16709	0.2644

VAR Residual Serial Correlation LM Tests
Null Hypothesis: no serial correlation at lag order h
Date: 12/02/19 Time: 00:31
Sample: 1970 2017
Included observations: 47

Lags	LM-Stat	Prob
1	7.716018	0.5630
2	9.567689	0.3866

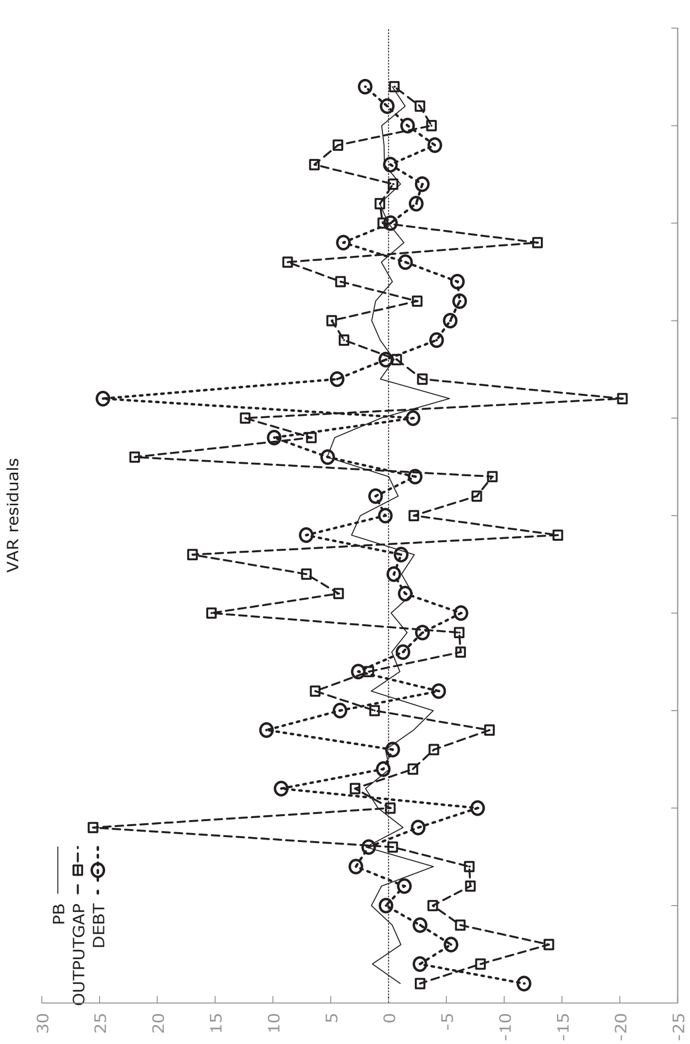
Probs from chi-square with 9 df.

VAR Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: residuals are multivariate normal
Date: 12/02/19 Time: 00:32
Sample: 1970 2017
Included observations: 47

Component	Skewness	Chi-sq	df	Prob.
1	0.063296	0.031383	1	0.8594
2	1.483553	17.24061	1	0.0000
3	0.875426	6.003236	1	0.0143
Joint		23.27523	3	0.0000

Component	Kurtosis	Chi-sq	df	Prob.
1	4.267693	3.147132	1	0.0761
2	6.922489	30.13077	1	0.0000
3	4.126056	2.483173	1	0.1151
Joint		35.76107	3	0.0000

Component	Jarque-Bera	df	Prob.
1	3.178515	2	0.2041
2	47.37137	2	0.0000
3	8.486409	2	0.0144
Joint	59.03630	6	0.0000


VAR residuals
PB
OUTPUTGAP
DEBT

OLS Residual Tests

Heteroskedasticity Test: White

F-statistic	0.906893	Prob. F(9,37)	0.5295
Obs*R-squared	8.494209	Prob. Chi-Square(9)	0.4852
Scaled explained SS	11.61650	Prob. Chi-Square(9)	0.2358

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 12/02/19 Time: 00:37
Sample: 1971 2017
Included observations: 47

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	8.269177	11.08223	0.746165	0.4603
DEBT(-1)^2	0.002358	0.007564	0.311735	0.7570
DEBT(-1)*OGAP(-1)	0.006134	0.015654	0.391822	0.6974
DEBT(-1)*PB(-1)	-0.002485	0.051120	-0.048608	0.9615
DEBT(-1)	-0.260877	0.578404	-0.451029	0.6546
OGAP(-1)^2	0.005551	0.007328	0.757568	0.4535
OGAP(-1)*PB(-1)	0.057396	0.051659	1.111055	0.2737
OGAP(-1)	-0.254971	0.579742	-0.439801	0.6626
PB(-1)^2	0.091163	0.136965	0.665589	0.5098
PB(-1)	-0.040795	2.071815	-0.019691	0.9844

R-squared	0.180728	Mean dependent var	3.712895
Adjusted R-squared	-0.018555	S.D. dependent var	6.784273
S.E. of regression	6.846924	Akaike info criterion	6.871778
Sum squared resid	1734.574	Schwarz criterion	7.265427
Log likelihood	-151.4868	Hannan-Quinn criter.	7.019911
F-statistic	0.906893	Durbin-Watson stat	2.112244
Prob(F-statistic)	0.529536		

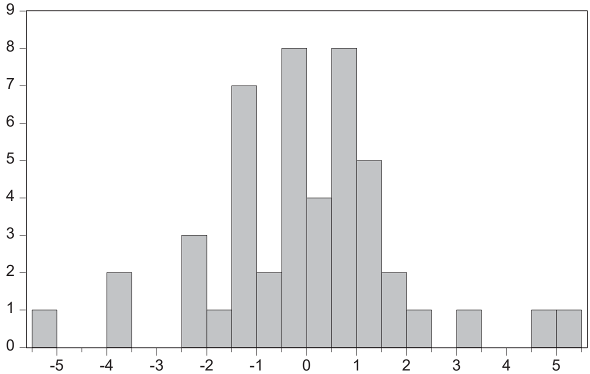
Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.632447	Prob. F(2,41)	0.5364
Obs*R-squared	1.406604	Prob. Chi-Square(2)	0.4949

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 12/02/19 Time: 00:38
Sample: 1971 2017
Included observations: 47
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.066401	1.300438	-0.051061	0.9595
DEBT(-1)	0.001886	0.035461	0.053181	0.9578
OGAP(-1)	0.005097	0.031245	0.163118	0.8712
PB(-1)	0.003693	0.191237	0.019309	0.9847
RESID(-1)	0.066243	0.246418	0.268822	0.7894
RESID(-2)	-0.168006	0.180990	-0.928259	0.3587

R-squared	0.029928	Mean dependent var	-8.86E-17
Adjusted R-squared	-0.088374	S.D. dependent var	1.947719
S.E. of regression	2.031961	Akaike info criterion	4.374623
Sum squared resid	169.2835	Schwarz criterion	4.610812
Log likelihood	-96.80365	Hannan-Quinn criter.	4.463503
F-statistic	0.252979	Durbin-Watson stat	2.028448
Prob(F-statistic)	0.935895		



Series: Residuals
Sample 1971 2017
Observations 47

Mean	-8.86e-17
Median	-0.011571
Maximum	5.312375
Minimum	-5.259238
Std. Dev.	1.947719
Skewness	0.063296
Kurtosis	4.267693
Jarque-Bera	3.178515
Probability	0.204077