Hacettepe University Graduate School of Social Sciences

Department of Public Finance

ESTIMATING A TIME -VARYING FISCAL REACTION FUNCTION TO APPRAISE PUBLIC DEBT SUSTAINABILITY IN TURKEY: 1970-2017

Cansın Kemal CAN

PhD Dissertation

Ankara, 2020

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To My Mother

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ABSTRACT

CAN, Cansın Kemal. *"Estimating a Time-Varying Fiscal Reaction Function to Appraise Public Debt Sustainability in Turkey: 1970 - 2017"* PhD Dissertation, Ankara, 2020.

This thesis appraises the public debt sustainability in Turkey by estimating a fiscal reaction function in time-invariant and time-varying (state space) settings. Succinctly speaking, this function gauges the scale of fiscal responses in the form of primary balance improvements to trim the excessive upward movements in the public debt so as to bring in a verdict about the level of fiscal sturdiness in the country. The data set used for this estimation covers the 1970-2017 period. According to the findings, the time-invariant estimation results are indicative of public debt sustainability albeit in a narrow perspective for the entire sample whereas time-varying estimation results point out to a transformation in the fiscal reaction rather than strict sustainability. The evolution of fiscal reaction parameter exhibits a shift from negative to positive which corresponds to a transition from unsustainable to sustainable debt position. This transformation trimmed the adverse effects of the concurrent positive snowball effect on debt dynamics and thereby initiated the public debt sustainability during early 2000s which did not exist before. The empirical findings are also suggestive of the fact that recent fiscal performance is not on a par with the past achievements and the fiscal reaction strength of Turkey has been waning gradually during the late 2010s. Coupled with worsening growth and real interest rate environment, the recent gradual downturn in the fiscal reaction competence of the government emits risks of a looming debt crisis reminiscent of 2001 whose impairing effects can swiftly permeate all sectors of the economy. In order to preserve sustainability, this trend should be reversed in a timely manner by policy alterations. Reducing extravagance and profligacy in public sector for restoring commitment to fiscal discipline through a back-loading adjustment and a full-fledged tax system restructuring are among the potential policies to be considered for facilitating the required primary balance generation.

Keywords: Debt Sustainability, Fiscal Reaction Function, Primary Balance, State Space Model, Ponzi Scheme

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INTRODUCTION

Turkey has a long history of economic instability induced mostly by indebtedness and malfunctioning fiscal policies. In particular, frequent unfavourable movements in the public debt dynamics were among the most profound hindrances to economic development in Turkish economy throughout the recent history. Thus, 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. It is very purpose of this thesis to implement an appraisal of this sort to contribute to the literature by gauging the degree of Turkish public debt sustainability in a historical perspective so as to comprehend the past trajectory of the indebtedness and offer caveats to avoid future challenges.

In particular, the main research carried out in this thesis seeks an answer to some questions including: 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 unsustainability? Based on the findings about the past and current status of public indebtedness, are there any alarming issues which raise concerns about the future trajectory of public debt in Turkey?

In order to find answers to these questions in various levels of stringencies, the fiscal reaction function was estimated in different forms in this thesis. Succinctly speaking, this function tests the existence of sufficient fiscal reaction to establish and preserve the sustainability of public debt. The results in the thesis indicate sustainability through a transformation to some extent but they are also indicative of heightened concerns about the near future based on worrisome pattern of parameters.

In view of these arguments, the primary motivation of this dissertation is to enrich the Turkish academic literature on public debt sustainability by introducing a time-varying fiscal reaction function using Turkish data covering the 48 years of history from 1970 to 2017.

To accomplish this objective and fulfil the gap in the literature regarding time-varying estimation of fiscal reaction function using Turkish data, the thesis is developed under three chapters;

The first chapter discusses the theoretical issues related to the public debt sustainability. It sheds light on the relevant terminology as well as formal derivations of the underlying equations of the model. This chapter also goes into the consequences of a failure in reacting to rising public debt properly. The chapter additionally covers the extent to which the fiscal reactions can be performed by the government and how the timing of reactions can be determined and why they are important. In short, the first chapter can be thought of as an overture to 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 so as to comprehend the current status of the literature on which the analyses of the thesis are grounded in order to make the academic contribution of the thesis more distinguishable. This chapter also discusses the alternative models which could have been used instead of 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 tool for public debt sustainability analysis.

The third chapter deals with the empirics of the thesis. Along with the design and the implementation of the empirical analysis, this chapter also introduces the data and its distinctive properties together with a brief outline of the economic history of Turkey 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 on the empirical results.

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

CHAPTER ONE

THEORETICAL ISSUES REGARDING PUBLIC DEBT SUSTAINABILITY

The goal of this chapter is 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 which guide the methodological part of the thesis are also included within the 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 of the thesis

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 the limitations of the debt sustainability framework.

1.1 AN APPRAISAL OF DEBT SUSTAINABILITY CONCEPT AND ITS IMPORTANCE

In this section, it is aimed 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 in abundance in the literature. The inconsistency between the statistical and theoretical definitions of the concept and the existence of various alternative definitions make the real-world sustainability assessments more difficult. 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 the economic history, borrowing has been an inevitable source of financing by enabling the countries to finance public needs which are beyond their budgetary capacity since they have scarce financial resources compared to the size of the financial needs of the society. Long-run infrastructure investments, for instance, are mostly financed through borrowing as they require significant amount of funding. Also, borrowing allows the cost of borrowing to be borne by the next generations who will, to 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 important 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 fiscal reactions. Yet, debt management is a very sensitive concept and misleading arguments might lead to devastating outcomes in the future as they will lead to wrong policy choices. For this reason, a proper and firm grasp of the term need 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. 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. Debtholder 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 large since the government borrows in various maturities. The government can shorten this period by repurchasing the securities in the market or wait until the date of pay off (Buchanan & Wagner, 1967, pp. 3-4). Literally for every country, debt is permanent and inevitable, but the real problem is not the existence of debt but the perpetual need to rollover the debt accumulation. The problems regarding public debt management occur when the existing debt matures which forces the government to find new sources of financing. The exigent financing which is required for continuous social expenditures is a major source of the debt management problem, and if prolonged, leads to debt sustainability concerns. Retiring or reducing the existing public debt is not a permanent solution to the debt management problem because the country will still have to acquire extra financial resources to refinance the remaining debt and also to make expenditures beyond the budgetary capacity.

Besides debt reduction, the government is also capable of altering 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 debt management malfunctionalities, 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 the modern economies. However, outlining the causes and consequences of unsustainability of public debt 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 displeasing and 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 of time. The word "maintain" presumably reveals the intuition behind sustainability. Using this analogy, it is safe to conclude that the public debt sustainability is, to a large extent, related with preserving (or maintaining) the value or the composition of debt throughout a large time span (IMF, 2011, p. 6). Also, according to Salsman (2017), the sustainability of the public debt is the capacity of the government to borrow prudently and affordably in order to provide public goods and services without sacrificing its sovereignty or the rights, liberties and prosperity of citizens.

In the literature, there are numerous other attempts by economists to define the 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 the 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 the economists. Nevertheless, even though these two terms are closely linked to each other, the solvency is in fact 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 sustainable fiscal policy as well (Horne, 1991, p. 2).

Another reason why there is no clear-cut definition of the public debt sustainability is the complexity within the scope of public debt profile of modern economies. For modern economies, to some extent, 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 sizeable amount of contingent liabilities which are very difficult to measure and far above the level of their outstanding assets. Contingent liabilities are in fact postponed borrowing for the government and similarly public debt can be thought

of as a postponed taxation. The existence of such contingent liabilities makes the 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 the economic history, the theorists had largely concentrated on the solvency of the government rather than debt sustainability. The Keynesian paradigm, for instance, gave rise to radical departures from the classical view in the public financial management as far as the solvency was concerned. An important milestone in this respect is obviously the Great Depression in 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 the Keynesian economists.

In fact, 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. Also, 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 important for sustainability considerations. In fact,

what matters is the capacity of the country to service public debt without being highly indebted in the long run. In other words, this modern theory emphasizes the importance of income generating potential of the economy rather than the existing amount of the public debt.

1.1.2 Why is Public Debt Sustainability Important?

One of the important 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 to the country can stop abruptly for a variety of reasons including shifts in global risk preferences or an adverse shock originating from international markets. Especially for developing countries which are in need of excessive external financing, such an instant halt in the financial flow can have impairing effects as the economy effectively demands continuous international finance to rollover the existing debt. Most of the time, such stops materialize very swiftly and the country oftentimes is caught off-guard. These sudden stops can be so severe that they might even lead to outflow of existing capital by reducing the sovereign credit rating. This, in turn, might potentially have 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 public financial 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"*. This 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). Also, 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 high level of reluctance to make new investments and thereby boost economic activity since the loss will be inevitable and the expected tax payments will be considerably high. Consequently, the decline in investments gives rise to lower economic growth and thereby to lower government revenues. The end result of this process is insufficient amount of funds for social and economic functions of the budget. Under these circumstances, the concerns about the default in the country rise with 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, contagion of economic downturn in certain sectors of the economy eventually leads to debt sustainability problems in the economy. In addition to this, the spill over effect echoes back to the private sector via channels of higher risk premium and lower credit ratings of the sovereign. Thus, in order to avoid such unpleasant sequence of economic events, monitoring the sustainability of the public debt thoroughly proves to be crucial from 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. This is when the fiscal reaction function comes into play. 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, underlying mechanism of debt dynamics need 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 and second objective is to formulize

the formal solvency condition. For this purpose, the nexus between debt and deficit need to be revealed properly. To do so, another variable namely the primary balance is incorporated into the analysis which can be defined as the differential 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 as a result of past debt and deficit realizations, and by excluding them from fiscal accounts, primary balance reveals the current fiscal policies in a clearer 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 is 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 the public debt sustainability considerations.

The first component of the public debt dynamics is the intertemporal budget constraint. The main 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 formulized by means of the notation listed below[1].

[1] The formal derivations in this chapter are borrowed from *"The Financial Programming and Policies Volume I*" training material of IMF Institute for Capacity Development.

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

$P_t Y_t$: Nominal GDP $P_t Y_t = (1+\pi_t)(1+g_t)P_{t-1}Y_{t-1}$

g_t : Growth Rate

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

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

The Equation (1) exhibits the public debt dynamics in a formal way. From this equation, the nexus between budget constraint and the law of motion of debt dynamics is able to 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 the 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

privatisation or seigniorage. However, for the time being, it is assumed that such flows are non-existent for the sake of simplicity.

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

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

Solving for D_t;

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

The 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. This 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 debt over time and can also be defined as a reorganized budget constraint. It relates the debt in period $t-1$ to the debt in period t. Manipulating this expression with some forward substitution, the intertemporal budget constraint and the solvency condition for the debt in the economy 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 into the second;

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

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 to the discounted value of primary balances. Here, the discount factor for primary balances and debt involve the number of years until which 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 debt sustainability perspective there would be no conclusion to draw.

The constraint to be imposed is the disallowance of *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 as 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 *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 the Equation (4) needs to be equal to be zero.

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

The restriction that the Equation (5) imposes does not, however, prevent the terminal debt from being positive and also it 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 in order 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 interest burden thereon (Burnside, 2005, p. 13). Thus, in order for the government to be solvent, the principal has to be serviced through the discounted primary surpluses occurring in the subsequent periods.

Hence, 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 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 the 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 future stream of primary surpluses. Also, the government might opt for attempting to attract new investors whenever a new fund is needed for repayment (Ponzi Scheme). However, obviously such a scheme gets

riskier in every round and will eventually and inevitably fail since it is impossible to bring in new investors into the system forever.

Nevertheless, using these two terms, a simple but intuitive academic definition of the 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 in a narrow perspective. This requires that the expected future primary surpluses cover the existing accumulation of debt. It might be stated that this is rather a soft requisite for sustainability since according to this definition, governments with 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, and it renders the sustainability contingent on expectations about the potential course of upcoming events which 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 by means of higher inflation which is high enough to outweigh the nominal interest rate leading the real 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 future flux of primary balances as a certain portion of 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 authorities. According to IMF and 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) and some level of painful economic policy adjustments in the form of retrenchment will be needed in the future.

In modern economic understanding, however, what really matters is not the level of debt but its position against the financing 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 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 sole magnitude of the public debt. For this reason, despite its restricted capacity as an indicator, 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, if the debt ratio is quite high initially, even a continuous decline in the ratio does not imply sustainability until the ratio reaches a certain level which is sufficiently low (Jha, 2012, p. 22). Thus, to add some more insight to the analysis, debt/GDP can be incorporated to 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,

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

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

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

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

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:

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

Using this equation, the influential factors on the debt dynamics can be analysed from different angles. 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, 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 and 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, 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 capacity to pay. The Equation (8) can also be illustrated in a phase diagram for a clearer understanding of the dynamics of debt. 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 remains 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 the Equation (8) reveals more insights about the debt dynamics.

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

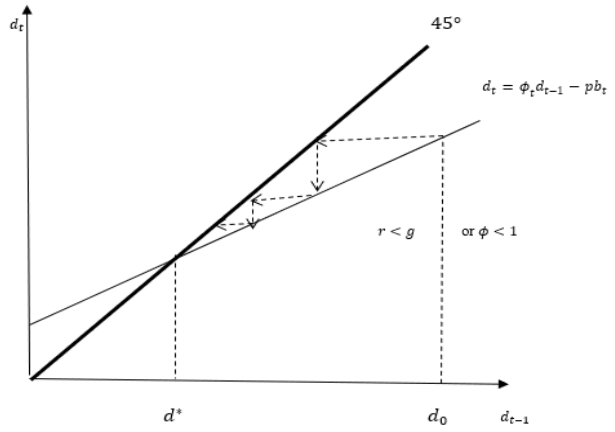
Subtracting the previous period debt d_{t-1} from both sides;

$d_t - d_{t-1} = \left[\frac{1+r_t}{1+g_t} - 1\right] d_{t-1} - pb_t$ or,

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

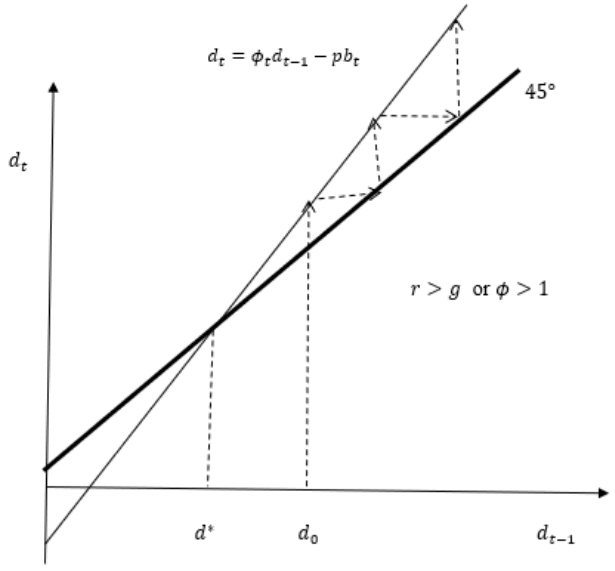
The momentum of debt and the governments' effort for stabilisation can be observed from Equation (9). The term in the brackets simply indicates the proportion of the debt accumulation arising due to interest reimbursements of the former period. The equation simply states that if the real growth rate 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 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

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

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

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

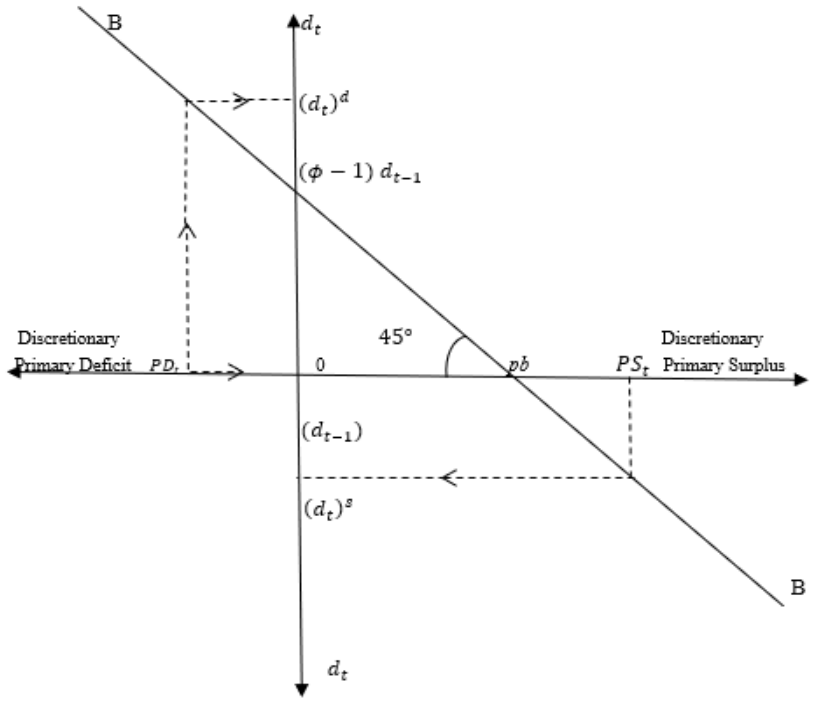
- The first determinant of the required primary balance is the amount of public debt itself. If the current extent of debt/GDP is quite high, then, seemingly large levels of primary surpluses are needed for reducing the current level of debt ratio and also for hindering it from increasing even further.
- Secondly, if the differential between the real growth rate and the interest rate is great, then the debt stabilising primary balance will also be high.
- Finally, the third factor is the availability of other sources of financing such as privatisation or seigniorage. The 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 represent a primary surplus and the left-hand side shows the primary deficit. The vertical axis is devoted to d_t and 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 the value of -1. This line intersects with the vertical axis above the origin if the interest rate is higher than the growth rate of the economy, whereas 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 intersect 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 primary deficit up to the intersection point of BB line and deficit sector of the primary balance axis (Makin, 2005, s. 288).

Figure 3 Debt/GDP Ratio and Primary Balance



Source: Makin, 2005

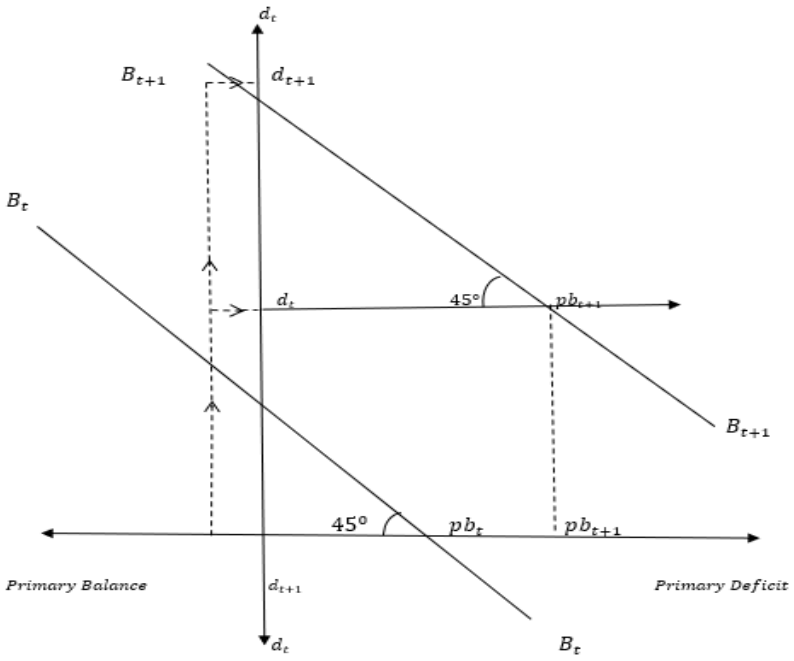
Along with the above analysis, the vicious circle between debt, primary balance and interest rate can also be illustrated with an augmented version of the Figure 3.

The 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 public sector stance and about 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 period $(t+1)$ leads to lower investments and therefore lower growth in addition to increased interest bill paid on the government debt. These two channels worsen the public finances therefore $B_{t+1}B_{t+1}$ 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 instable 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 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 the 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 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 primary balance as a tool. It can be simply pointed 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 again a positive initial debt, 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 reaction of the government via primary balance. If the primary deficit is high enough, the debt might increase even in the event of a favourable outcome from the automatic dynamics. The favourable outcomes only refer to a 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 the 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 $\phi > 1$, then 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 on 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 arising from 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 the 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 differential between interest rate and growth rate in the economy. This point indicates that the capacity to pay and the speed of increase in the costs of debt must grow equally in order 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 which are 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 will 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 positive fiscal reaction by means of primary surpluses. Hence, how the government reacts to the debt level is crucial for the 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 useful 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 in an operational way to make a concrete reasoning about the debt sustainability standards of the country.

To understand how Bohn (1998) managed to formulize the term of debt sustainability in an operational manner, it is useful 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 need to be smaller than the discounted value of the primary surpluses. This simple condition is effectively a significant constraint on the future fiscal policies and operational formulizations of debt sustainability should incorporate this restriction to the analysis. However, the above-mentioned definitions of solvency which are based on stock of fiscal liabilities and primary surpluses are in fact 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. The fiscal solvency described early in the work, is a sole arithmetic equation, and there are numerous ways of fulfilling the same intertemporal conditions.

What solvency condition implies is that, the accumulated debt needs to be matched by 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 and 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 which has been discussed so far from the fiscal policy perspective, however, the governments can also 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 left-hand side of the equation and be solvent without needing to raise primary surpluses (Burnside, 2005).

Those measures, however, can be considered as an additional tax on the creditors which is an extra burden for the economic agents. In addition, they will undercut the overall credibility of the sovereign and thereby will have economic consequences especially in the form of limited future stream of credits which eventually leads to higher borrowing costs in 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 need 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 the fiscal solvency and this dichotomy has important implications on the definition of sustainability from an operational perspective. As the “bad” ways of fiscal solvency have undesirable ultimate outcomes, the public debt can be deemed sustainable only if it is reached by implementing “good” ways of fiscal solvency measures. From this argument, it is quite clear that preserving debt sustainability is more challenging than preserving solvency. Put differently, the solvency condition per se is quite soft a constraint from fiscal policy perspective. Also, the debt sustainability analysis grounds on the

governments' commitment to adhere 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 in depth analysis of fiscal tools and potential future behaviour of the fiscal authorities. 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 keep running adequate primary surpluses and stay on the "good" side of the equation, but whether it can transform this choice into binding commitment boils down to a combination of its real efforts and the external conditions which are uncertain and hard to predict (Greiner & Fincke, 2015).

Sustainabilitywise, there is always uncertainty incorporated into the picture as the solvency does not always imply sustainability. Bohn (1998) claims that stationarity of the data is important 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 a random occurrence of a favourable event or it can be associated with the fiscal policy design. Hence, there is a significant amount of uncertainty surrounding the debt sustainability analysis. For this reason, in order to reduce the scale of subjectivity and improve concreteness of the debt sustainability analysis, the fiscal behaviour of the government needs to be modelled to determine 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 avoided 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, subjective outline of the best fiscal policies and responses by the government are not needed

the fiscal behaviour optimization. Instead, the link between the debt dynamics and fiscal behaviour can more analytically be tested by means of fiscal reaction function. In this sense, the model can be thought of as a combination of average form of fiscal policies which are basically the fiscal responses of the sovereign 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 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, in fact, 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 formulized 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 solvency condition in Equation (6) above, therefore it is strictly connected to the very notion of sustainability. As we mentioned earlier, the solvency is a prerequisite for the sustainability.

- It does not fluctuate as a consequence of interest payments since interest payments are the consequences of past policies which are no longer controllable. In other words, the primary balance eliminates the interest reimbursements on the existing debt and responds systematically to debt level of the previous periods and to the output gap procyclically or counter-cyclically. These responses are vital from operational perspective.

The primary concern of this function 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 there are also several "good" ways of running fiscal policies and each of them has entirely different impact on the economy. The sovereign can raise primary surpluses by means of different adjustments including taxes or lowering expenditures and the composition of the involved policies is also crucial for the quality of the eventual outcome of implemented policies. 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.

Without doubt, the primary explanatory variable of a typical fiscal reaction function is the previous period debt level. The magnitude of the reciprocation to the debt level of previous period is an important means to specify the fiscal behaviour of the government. The solvency condition implies that any expansion in the public debt should eventually be matched by the discounted future primary surpluses. Besides, the transversality condition restrains the government from postponing the primary balance generation forever. Hence, the expected sign for 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 the 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 which 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 suitable for estimation, some derivations on the debt dynamics equation are needed.

Iterating Equation (7) for one period reveals;

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

The 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 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. The ultimate dynamics of the debt path is determined by a combination of these two forces. 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;

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

The 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 the growth in the debt is sometimes called *"snowball effect"* (Debrun, 2015, p. 4).

In most countries and most of the time, r is greater than g. Therefore, mostly, in order to keep the $\Delta d_{t+1} = 0$, the government needs to run primary surpluses for stabilising the public debt. If debt grows faster than the economy, in the medium and long run the government would continuously increase taxes and cut spending to compensate. 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 debt will grow exponentially. Therefore, the analogy to 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 despite the fact that it is not a normal situation and also r *will* exceed g eventually anyways. In such a case, ceteris paribus, 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).

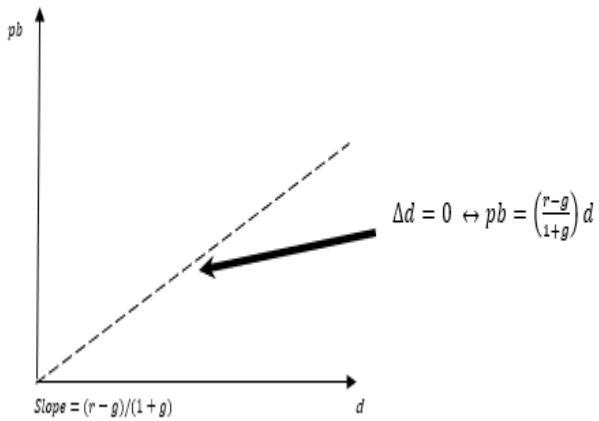
As long as $\Delta d_{t+1} > 0$, the primary balance will continue to improve until it reaches a level which is adequate for stabilizing the debt. The stabilization of the debt materializes when the primary balance is big enough to overcome the negative force of the "snowball effect". Therefore, the 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 which can be measured by the amount of change compared to previous period. A positive reaction by means of primary surpluses to past debt is crucial for preserving the solvency.

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

On the diagrams below, the snowball effect and how it automatically accumulates debt via interest payments are illustrated. Also, the fiscal reaction function and how it measures the responses of fiscal behaviour to the debt dynamics are depicted on the same figure as well.[2] On the horizontal axis the debt/GDP ratio is located and 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 positive a snowball effect where $r > g$.

[2] 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. The end result of 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 because $\Delta d = 0$. The primary balance is keeping the debt stable over this line. In the upper zone of the demarcation line, primary balance is sufficiently larger than its debt stabilising level. As a result, 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 rising debt/GDP ratio.

Reversing the argument above, the reason becomes obvious. 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. As the slope of the line is based on these two variables, the size of the zone will be determined by their magnitude as well. As the interest rate rises, the line becomes steeper and the zone below it becomes larger which increases the likelihood of an unsustainable debt with possibly enlarging

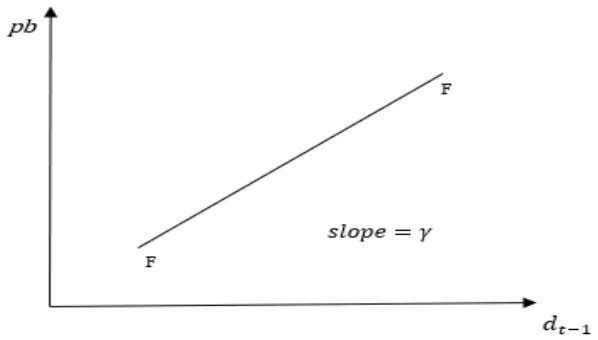
level of debt/GDP. However, the point here is to explore how the fiscal reaction function fits into the picture.

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

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

For simplicity a linear fiscal reaction function is assumed. As indicated earlier, the expected sign for the lagged values of 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 quite 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 important 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, then the government is reluctant to react to increasing debt. Putting all these pieces together, 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



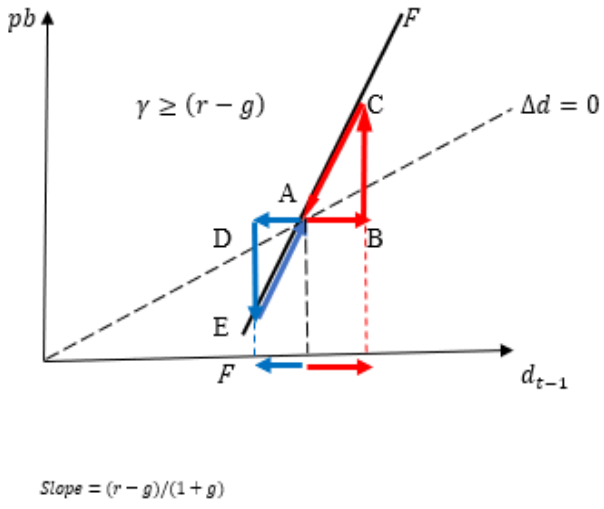
Source: Debrun (2015)

The 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 Figure 1 and 2 with the variables assigned to axes. On 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 on this diagram is that the FF line is steeper than the dotted demarcation line. This essentially guarantees the stability of the equilibrium. This 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 red arrows illustrate a positive shock to 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 rising the primary surplus which brings it to point C.

Figure 7 Equilibrium and Stability



Source: Debrun, 2015

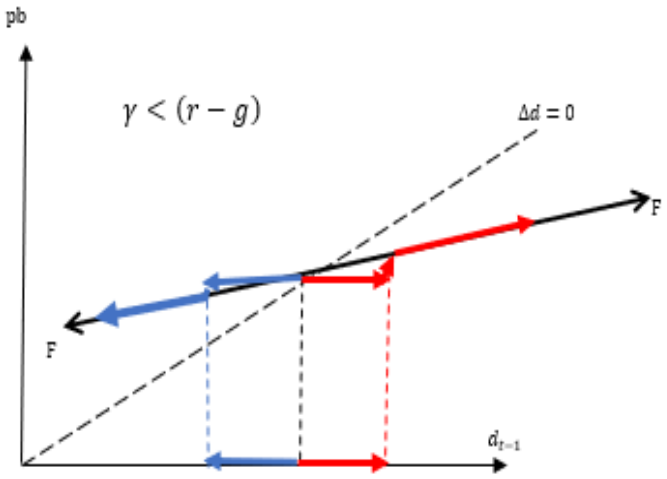
An important worth noting about point C is that, it is above the line which demarcates the stable and unstable zones. Above this line, the debt/GDP ratio falls.

The reason is simply the amount of primary surplus raised which outweighs the primary surplus needed to stabilise debt. This 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 a privatization. This pushes the country to the point D on the diagram. In this case, the debt will fall due to an external shock which will make the government more reluctant to run primary surpluses. This reluctance of the government will lead to lower primary balance and force the country to move to the point E which is once again on the line like the point C of the previous case. This time, as the primary balance falls behind the debt stabilising level, the debt will keep rising. The end result will be the same as the previous case and once again a stable equilibrium will occur (Debrun, 2015, p. 7).

The unstable equilibria, on the other hand, occur when the assumption about the slope of the fiscal reaction line is lifted. If it becomes flatter than the demarcation line, the equilibria might be unstable due to the fact that the government is no longer capable of responding to 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



Source: Debrun, 2005

Slope $= (r - g)/(1 + g)$

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 red 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 debt. In this case, the response of the government 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. This is called "explosive debt".

Similarly, when a negative shock hits the debt/GDP ratio, once again, the economy moves off the equilibrium and debt will fall. As a response, the government will reduce the primary balance. However, in this case the economy is above the stable line which will bring 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. This 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 first shock hitting the debt ratio. In this case, no debt level will be consistent with the debt sustainability. The level of debt which corresponds to the intersection point of the two lines is the threshold debt level. Above that, the debt is explosive and unsustainable, and below that debt is implosive and ever falling. Hence, in order 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 the public debt sustainability is guaranteed. Otherwise, when the strength of response to debt movements is low, then there will be a debt limit above which the debt will be unsustainable.

The strength of the response can be measured by the relative comparison of the snowball effect and the value of γ. In other words, marginal increase in the primary balance needs to be higher than the real interest rate growth differential, $r - g$. More importantly, despite the fact that a shallow response is adequate for fiscal

solvency according to Bohn (1998), it does not prevent the explosive debt from showing up which is totally 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 an uncertainty associated with this parameter to some extent. The uncertain conditions in the economy shape the fiscal behaviour and parameters which drive the movements of the equilibrium.

The components of the snowball effect, r and g are intrinsically uncertain as their future levels cannot be known in precision. This uncertainty directly affects the slope of the demarcation line above. As a result of that, 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 in the 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 stabilize debt by using primary balance as a tool is mostly unpredictable and this degree is very important 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 a very low but unsustainable debt, or conversely, with a very high but sustainable debt equilibria. 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. Due to an external

shock, for instance, 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 primary balance as a tool. This situation is called *"adjustment fatigue"*. In this case, the prolonged rises in debt leads 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 the public debt concerns. Higher fiscal space enables the government to make higher spending on the public welfare such as infrastructure, transfers so forth. Clearly, a highly indebted country will be forced to prefer to invest less on the overall welfare of the country, whereas a country with 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 favourable growth environment is reached in case of a large 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 and by analogy, the fiscal reaction strategies might have impairing 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 it needs to respond to increasing debt to bring it back to stable levels. One of those strategies involve 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 in order to reach 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 policies are employed mostly when the government faces harsh financial restrictions or when it needs to build credibility immediately, whereas the

latter type is oftentimes preferred when the government has enough time to design high quality measures. As back-loading entails a form of adjustment which are generally time consuming, the responses need to be credible enough to positively alter the risk premium of the country with a high debt level. Hence, the timing of the policies is quite important for their ultimate achievements to be as desirable as possible.

The aspiration level of the government for reducing public debt to a desired level, determines the amount of time it will take to reach that level. If the government is impatient about reducing debt, the trade-off of such a front-loading policy will be very high levels of primary surpluses exerted for several consecutive periods which could be detrimental for most parts of the economic society as it will have to involve immediate tax hikes or reliefs in government spending. However, in the case of back-loading, the debt stabilisation is achieved with 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 fiscal reactions have also negative impact on the overall macroeconomic indicators as well. 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 the fiscal reactions. Fiscal consolidation, in fact, affects the economic growth via multiplier channel. If the multiplier is large, the output will be reduced substantially. In addition to that, the fiscal consolidation also exert influence on debt by changing the risk premium. A successful fiscal consolidation reduces the risk of default and thereby improves the credibility of the government which lowers the interest rates and consequently increase the GDP level by stimulating investment.

Conversely, depending on the extent of automatic stabilizers, the economic growth enhances the primary surplus. Even though the government revenues go hand in hand with economic progress, the spending can increase in economic recession especially in economies 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 demand becomes larger. Therefore, higher multipliers decelerate the growth by quite a large margin. Such a scenario is sometimes called *"doom loop"* in the fiscal literature (Mullineux, 2014, p. 14).

In this case, a "loop" between fiscal reaction, lower growth and higher deficit is established in the economy. Mostly, such a loop is created unintentionally by the policy makers by the unfounded pessimism pumped to the economy. This prolonged pessimism leads to a hysteresis and ever falling GDP levels. In such a case, the economy faces a higher deficit and thereby higher debt level instead of the intended lower levels. 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 a bankruptcy is followed by a bailout.

However, as it does not address the real structural flaws of the system, it only helps the cycle to grow with no genuine regulations which ultimately gives rise to crisis in perpetuity. Therefore, it proves crucial for the policy makers to choose right form and timing of intervention to establish the 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) lists these shortcomings as follows:

- A climbing debt/GDP does not always indicate an unsustainable debt path. According to them, public debt may increase due to consumption smoothing, investment projects and economic reforms which are in fact 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 the existence of a positive reaction to pay off

the increasing debt which omits the future return of investments. These future returns may occur even in the absence of positive fiscal reaction 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 the stabilization of public debt instead of the value it converges to. Nevertheless, especially for 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. If the government alters its debt position by lowering the portion of short-term foreign currency debt and enhancing the portion of national currency denominated debt with longer maturities, the overall riskiness of the government will be reduced dramatically, despite the fact that 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 significant amount of assets in several forms which improves 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. In addition, the contingent liabilities are also oftentimes excluded from the analysis as well. This type of liabilities generate 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 important in the sense that 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, 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 tremendous amount of data and information which makes the analysis extremely sophisticated and difficult to implement therefore the analysis in this thesis 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 debt sustainability analysis but for a large array of reasons, some of those models are not appropriate for the very purpose of this thesis while the fiscal reaction function appears to be most suitable model. Therefore, this chapter exclusively concentrates on the theoretical and empirical literature on the fiscal reaction function so as to disclose the underlying reasons for the appropriateness of the fiscal reaction function for the analysis and discusses how the other models compare. Also, the chapter attempts to determine how this thesis reconciles the existing empirical literature on the public debt sustainability in Turkey.

In the view of 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 and secondly it gives a review of the theoretical and empirical literature regarding fiscal reaction function which is the model used in the third chapter for empirical analysis.

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 which serves the function of facilitating 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 which has been used by officials with some country specific modifications. The market access countries, as the name suggests, are the ones which can borrow in the international market,

should they need funding. Those countries are mostly the advanced economies and also the emerging economies such as Turkey.

The MAC-DSA is an inherently forward-looking tool which 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 with 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 riskiness of the country as well as 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 which are likely to prevail during the course of the analysis. Apart from the regular macroeconomic variables, the analysis in the MAC-DSA also incorporates contingent liabilities so as to reach more country specific results. The calibration of contingent liability shocks is performed with 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 so as to realistically simulate the circumstances surrounding the economy. As an outcome, the vulnerabilities of the economy can effectively be portrayed in the template (Jha, 2012, p. 24).

In the MAC-DSA, 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 the 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. Different 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. Building up country specific scenarios, a five-year horizon of the public debt can be simulated by means of the template. Running this kind of stress tests 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 which are allowed to vary endogenously are very limited. Thus, the template itself and the stress tests are seemingly restricted. Furthermore, it allows very unlikely 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 very 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 very large amount of time series data which is not available for our 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 the literature of public debt sustainability 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 has to be made by the researchers. The Barnhill-Kopits model aims to incorporate associated uncertainty into the analysis. Value-at-Risk is originally used in portfolio analysis whereby the potential losses of existing portfolios can be calculated. It computes worst likely loss of the portfolio for a given time span and for a given confidence level. To illustrate the point, we can consider an example. If we say that the one year 90 % loss for a portfolio is one thousand, it means that annual loss on the portfolio is bigger than or equals to one thousand with 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 the worst-case scenarios. In their model, Barnhill and Kopits (2003) treat the country as if it was a firm. Their ultimate goal is to determine the net value of the government and calculate the probability of that value hitting negative levels which can also be thought of as 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 have an effect upon the sustainability of the fiscal stance. The analysis is based on the income structure of the public sector 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 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 by postulating that if $V=0$, the intertemporal budget constraint binds. According to the authors, 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, 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 the past data. This

point can 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 extremely challenging to do so.
- Thirdly, the model suffers from data limitations as well. The model asks for a large data set containing assets and liabilities which is not available for many countries.
- Finally, it is based on very stringent assumptions which reduce its sensibility.

Due to these shortcomings, Value-at-Risk approach is not preferred in this thesis for analysis. 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

In their influential paper, Morada and Vidal (2004), assess the debt sustainability in a general equilibrium setting. They design their model using an overlapping generations model with endogenous growth. In this model, the endogenous growth originates from productive effects of expenditures on education. The contribution to human capital improves efficiency. Unlike IMF and Value at Risk models, the general equilibrium setting allows the interest rate and growth rate which have significant impact on the long-term sustainability of the public finances to be determined endogenously within the model. The proof for 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 human capital of a person is determined in the first period by the human capital and education spending by his parents. The process of formation in the 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 try to maximise their profit.

The government levies taxes, makes transfer payments, makes expenditures and services existing debt and interest payments.

By means of two differential equations, Moraga and Vidal (2004) portray the evolution of the 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 in the fiscal policy secure the fiscal sustainability only in a new equilibrium.

However, despite the fact that 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 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 quite narrow.

Taking those challenges and shortcomings into account, this technique does not appear to be a suitable model for this thesis. However, once calibration and time horizon issues are overcome, it can reveal insightful results 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 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 the public debt is largely related with the intertemporal solvency. The existence of solvency is largely a function of the behaviour of the fiscal variables. For the 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 stance of the economy heads towards unsustainability. The sustainability of fiscal position hinges on the preference between public debt and taxation.

The literature on the time series approach to public debt sustainability is to large extent based on the logic described above and the academic contributions are plentiful in this field. In this section, the time series-based contributions will be evaluated with reference to 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 important standards for the debt sustainability but has to be restricted to avoid the 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 the 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 and also 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 the sustainability of the public debt. If they are stationary, then sustainability can be assumed for the public debt.

In addition to the stationarity, the cointegration can also be used to test sustainability of the public debt by employing some auxiliary variables to make the Equation (3) more operational. Assuming that 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;

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

As it clear from the first chapter, the second component on the right-hand side of the Equation (16) has to be zero in the limit to secure the 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 their degree of stationarity is different from each other, the fiscal policy will not be sustainable whereas the existence of cointegration implies the sustainability thereof.

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

Apart from Afonso (2005), another seminal contribution to the argument was proposed by the Hamilton and Flavin (1986). This model aims to test whether the budget constraint is met in the manner 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 that of 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.

The main point behind this argument 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 need 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 the 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 is not applicable

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 are 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. The stationarity of budget deficit can be evidenced by a cointegration of revenues and expenditures.

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 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 due to the fact that the divergences of the debt from future stream of primary balances last for long periods. Hence, the existence of unit root in debt series might still be compatible with the sustainability of public debt.

Another contribution to the theory of public debt sustainability within 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 noticed, they use deficit rather than primary balance for analysis. In addition, 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;

$\Delta T_{t+n} \equiv T_{t+n} - T_{t+n-1} = \alpha_1 + \varepsilon_{t,1}$ 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 common long run pattern, then it is safe to conclude that No-Ponzi condition is satisfied. The reason is that the existence of common long run pattern indicates that the government responds to the movements in the debt by adjusting revenues, spending or both so as 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 $0 \leq \lambda < (1 + r)$.

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

Quintos (1995) makes a contribution by introducing the distinction between the weak and strong sustainability. Effectively, he combines the findings of Hamilton and Flavin (1986) and Hakkio and Rush (1991). He states that in order for the strong sustainability to occur, the debt series need to be I(0). 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).

Despite the fact that several other papers can be named which apply similar approaches to the debt sustainability analysis, it is quite clear that this sort of tests are not very informative and according to (Bohn, 1998) have remarkable potentials to be flawed in terms of their conclusions about debt sustainability for a variety of 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 serious flaws and misleading results in the end. They can reach misleading conclusions about sustainability because the analyses are based solely on imprecise test outcomes. When conducting research on the debt dynamics, the formal tests might reveal mixed results since they lack power and precision to determine the stationarity especially in small samples. Bohn (1998) indicates that debt/GDP and primary balance/GDP ratios oftentimes exhibit prolonged persistence which makes it very tough for the formal tests to distinguish whether the series are in fact stationary or not.

In the same paper, he claims that stationarity can in fact safely be assumed for those series. He argues that, at least for 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 ADF test when the sample size is small. Their sample size has 42 observations which is not very long 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 of them, the formal tests are prone to reaching misleading results as they are testing ad hoc sustainability by nature.
- Another challenge associated with the time series approach is the fact that they are intuitively backward 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, design of

the unit root tests makes the analysis more ambiguous unlike 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 as a result of 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

Taking the above-mentioned shortcomings of the time series approach into account, Bohn (1995) and Bohn (1998) propose a new model-based approach to debt sustainability, namely the fiscal reaction function. Basically, 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 the sustainability of the public debt since they might reveal misleading results because of the weaknesses of the unit root tests.

Challenges to reject the unit root mostly originate from the very characteristics of debt/GDP ratio which intrinsically contain more information than the budget balance. Hence, the debt/GDP ratio might rise or fall not only due to the design of the fiscal policy, but also as a consequence of other factors affecting the dynamics of debt and this fact 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 direct control of the government but it still has remarkable impact on the debt/GDP ratio. Because such auxiliary factors have direct effect on the dynamics of the public debt, the scope of the debt sustainability analysis should definitely and solely be extended such that the impact of the fiscal policy design on the debt realizations are accounted for in the analysis. Even the regular fluctuations and normal shocks to the GDP or the real interest rate might impair the time series properties of the debt series and the vulnerability of the time

series properties makes it harder for the formal tests to reject the unit root and 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 and 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;

$(t_t - g_t) = \beta d_t + AZ_t + \eta_t$ where,

Z_t is the vector of cyclical elements that might have 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 back to its trajectory.

According to Bohn (1998), regardless of other conditions, a positive response is sufficient for debt sustainability. However, Canzoneri et al. (2001) claims that the response should be non-negative throughout the sample range for the fiscal sustainability to be secured. From 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. According to them, if the coefficient is positive "on average" throughout the sample, then it is sufficient for debt sustainability to occur. 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 fiscal policy perspective, by modelling the primary balance and other components separately, the fiscal reaction function captures the sole response of fiscal authority to up and down swings in the public debt. Focusing merely on the dynamics of the public debt from the perspective of fiscal policy design is effectively a more comprehensive way of conducting fiscal sustainability analysis.

From 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 present value of the public debt converges to zero at the limit. Furthermore, 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 papers since they do not incorporate the higher order integration of variables to the analysis. He also proves that the cointegration between revenues and expenditures are not needed to for No Ponzi condition to hold. Hence, according to him any finite integration of variables of revenue and expenditure 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 $E_t\left(\lim_{n\to\infty} \rho^n D_{t+n}\right) = 0$[3] (Bohn, 2007).

As a result of these findings, Bohn (2007) concludes that times series techniques such as unit root and cointegration are not convenient and are insufficient for reaching 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 in turn leads to the conclusion 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 about the fiscal policy performance of the government. According to him, greater order of integration implies higher macroeconomic risks in the long term.

To recapitulate, 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. The public debt sustainability can more properly be implemented by focusing on as to whether the government puts sufficient amount of effort into reacting to the oscillations in the debt ratio by means of 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

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

identified as unsustainable by the univariate approach or a trend stationary debt ratio which would misleadingly be classified as sustainable, just to name a few.

In the view of these arguments, it can be stated 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 debt and an indicator of the economic activity such as output gap. Additionally, in the literature, there are several studies which include the autoregressive term of the primary balances as an explanatory variable to account for the inertia in the primary balance. Despite the fact that many other economists concur that additional variables are needed, modifications appear to be country specific and they are mostly reshaped by the data limitations.

In its reduced form, however, the 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 corrective effort, we can conclude that the debt will eventually converge to a sustainable level (Bohn , 1998).

Based on these considerations, for the numerical analysis in this thesis for 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 a 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 as well because the government budget is prepared on an annual basis in our country. Hence, it is more suitable to use lagged values of public debt in the equation with annual data for Turkey as well. In other words, the sensible data needs to have yearly frequency 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 largely characterized by instabilities. Besides, the recent economic history of both countries involve 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 fiscal reaction function as a tool for the analytical research in this thesis.

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

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

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

Then, they rearrange it to obtain the level of primary surplus which will keep 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, they 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 whereas a negative value of the coefficient implies a fiscal response which 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 back towards its mean. Therefore, by forcing the debt to revert to the mean, the government guarantees the sustainability of the public debt. Hence, it is crucial to test whether β_3 coefficient is positive to examine the sustainability of the public debt. Excluding inflation and seignorage, this 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 which makes it practical for modelling developing country data. Bohn (1998) argues that a positive reciprocation by the government contains valuable information about the sustainability even without incorporating the interest rate and growth. In the literature, however, there are large disputes about this topic and 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 economy. Obviously, the developing countries are more prone to economic shocks and volatilities, thus, this feature of the model proves useful 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 surpluses on a perpetual basis to service public debt as it requires to raise taxes continuously which is against the postulations of tax smoothing argument. Yet, refraining from running positive corrective fiscal responses to debt fluctuations might lead to explosive indebtedness which is also detrimental for 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 as is, is that it will reveal a result which is free of time dimension. In order words, the results from the above equation will be time-invariant. However, Bohn (2008) gives a hint about the time-varying properties of the fiscal responses by the government to the debt dynamics. The intuition behind imposing time-variance to the structure 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 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 corrective fiscal response of the government is a contingent action which 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 the sustainability in the context of time-varying coefficients. According to them, if the coefficient is positive "on average" throughout the sample, then it is sufficient for debt sustainability to occur. 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 is included in Greiner and Fincke (2009). They extend the argument to be more precise about the decision rule for public debt sustainability. According to them a positive coefficient does not necessarily indicate that debt/GDP ratio will remain steady or will converge to level zero. There are other conditions which need to be fulfilled in order for the sustainability to be reached. In particular, in addition to a positive sign of 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 stronger requirement needs to be fulfilled by the government to have a sustainable debt position.

2.2 EMPIRICAL LITERATURE ON THE 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 fiscal reaction function to gain an understanding of the results and model variations in other countries so as to reconcile the contribution of this thesis 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 on their stringent assumptions about time series properties of the indicators. 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 primary balance policies of the government 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 paper, his research mainly focuses on the existence of the corrective measures to react to accumulating debt. According to him, the underlying reason in the movements in the debt ratio need to be determined so as 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. Debt/GDP is surrounded by several uncertainties which make 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 for accounting for the cyclical fluctuations. In this case, a positive response of primary surpluses is adequate for sustainability in a weak perspective. Based on the evidences of his empirical estimations, public finances have been sustainable in the US despite long periods of primary deficits which is 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). According

to him, if no other explanatory variables are added to the equation, regressing primary balance on public debt will bring about omitted variable bias which will lead 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 is counter fiscal reactions to public debt in the U.S. He claims that the primary surplus is an increasing function of debt/GDP and 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 reaction parameter. This result indicates that primary surplus reacts positively to upward movements in public debt guaranteeing intertemporal solvency and thereby 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.

Barro (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 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 in a historical perspective the U.S. government has been performing positive reactions to upward movements in debt/GDP ratio by means of primary balance improvements. Such a positive response implies 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 the criteria for public debt sustainability. 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 the 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 in the series.

For this reason, he claims that the most credible evidence for sustainability is the existence of robust positive responses primary balance scaled by GDP to the upward movements in debt/GDP. In this paper, he offers several extensions to the fiscal reaction function theory such as general equilibrium setting, non-linear estimations and time-varying estimation. He claims that 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 so as 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, the coefficient of public debt needs to be greater than zero and remain in the positive zone for a large portion of the data set. He states that a 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 so as to guarantee that the solvency is not obtained with financial repression or monetization. Empirically, Bohn (2008) extends the data set to cover the period between 1792- 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 robust positive reaction of government to lagged values of public debt which is an indicator of sustainability. The empirical evidences suggest that growth realizations covered the interest payments on U.S. debt throughout the 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 indebtedness of the country which arises due to uncertain nature of economic events and policies. Their approach involves a simulation algorithm for

the debt dynamics involving shocks to several variables and the policy responses to these shocks by the government. They put emphasis on 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 which are basically probability distributions for each year ahead. Their approach involves a seemingly versatile structure which 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 path of public debt. Secondly, they estimate a fiscal reaction function in a panel data setting. According to them, panel approach is not suitable for fiscal reaction function theory and once sufficiently long data set can be found for each country, the estimation of fiscal reaction function needs to be country specific.

In the third step, they combine the first two blocks and produce 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. The prominent feature of this paper is its ability to endogenize the uncertainty in the public debt sustainability framework by incorporating probabilistic approach rather than 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. Indeed, during this period no such dramatic increase in the 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 the ones which violated the Maastricht criteria more than once. They apply the methodology proposed by Bohn (1998). Their evidence indicates that despite some violations of

Maastricht criteria, the countries pursue fiscal policies which are consistent with debt sustainability in that they put sufficient fiscal effort to trim the fluctuations in debt/GDP ratio. However, they 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 for growth in the long run.

Budina and Wijnberger (2007) combines different approaches to fiscal sustainability 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 the public debt sustainability. This indicator is called required deficit reduction which is 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 the inflation, fiscal deficits and public debt management to augment the analysis by incorporating the interaction between the policies. Similar to Celasun et al. (2006), they run stochastic simulations, calibrated shocks and stress test. 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 which is consistent with debt sustainability definitions. However, they make a caveat about the debt structure of Turkey and potential risk of rollover due to the precarious structure of public debt in Turkey.

Mello (2011) investigates the sustainability of public debt in Brazil by means of fiscal reaction function. He uses a Monthly data set from 1995-2004 for this purpose. He concludes that the Brazilian government reacts to the changes in 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 were able to exert higher level of response to debt movements. According to him, the government generated fiscal efforts even during the 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 the economic

performance. The findings in this paper imply that the government responded to upward movements in debt in all levels including local governments. Also, especially in 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 estimation results of fiscal reaction function. However, to preserve the status of public debt sustainability the government need to keep running primary surpluses on a continuous basis. 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 the government finance.

Fincke and Greiner (2011) estimate the fiscal reaction function to test the sustainability of the debt policies 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 with the exception of Greece and Italy. This paper is an augmented version of Greiner (2007) by the incorporation of time-varying setting. According to the authors, the data generating process is nonlinear and uncertain. Therefore, transforming the OLS model in Greiner (2007) into time-varying setting brings the model closer to the real data generating process. Also, time-varying setting enables the detection of any change in the parameter and facilitates the analysis to determine as to whether it is positive for the entire range or not.

Stoica and Leonte (2011), analyse the fiscal troubles of Greece 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 cover the 2001Q1-2008Q2 period. However, they reach insignificant coefficients for 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 were able to raise primary surpluses when they face an increase in debt following a Ricardian policy.

Burger and Marinkov (2012) estimate the fiscal reaction function in a 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. Taking the difficulties of forecasting macro variables into account, they propose a fiscal rule which sets a target level for fiscal variables. According to the authors, the government can set 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), investigates 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 sustainability of public debt and those fiscal policies is rather weak. They estimate a pooled cross section fiscal reaction function with GLS for seven countries including Turkey for 1998-2008 period. According to the authors, unlike other countries, the interest rate and growth environment was not favourable for debt reduction during the sample. The primary surplus, despite being positive and large, was not sufficient to return the public debt back to sustainable levels. They find that at low levels of debt the primary balance responds to public debt positively, but as the public debt level increases, the strength of the fiscal reaction falls indicating a fiscal fatigue.

Burger et al (2012) elaborate 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 1990s onwards. According to their findings, since 1946, the government in South Africa performed well in improving primary balance to reciprocate to rising debt. The authors claim that the past performance of the government in reacting to the upward

movements in public debt gives a hint about the future trajectory of the fiscal policies in the country. Based on the estimations, they run forecasts about the path of public debt in the next years. According to forecast estimations, the public debt will remain sustainable in the near future. All estimation techniques reveal positive fiscal reaction coefficients which supports the idea that public debt is sustainable in South Africa. The output gap parameter is positive indicating a countercyclical fiscal policy in the country. Also, the autoregressive term in the equation has positive coefficient which signals inertia in the fiscal management. According to estimation results obtained from TAR model, the authors test the strength of fiscal reaction in different phases of business cycle with strong evidence for countercyclical fiscal policies. Also, fiscal sustainability is evidenced by positive reactivity of the government and for the estimation period, the cost of borrowing remained moderate which facilitated the 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 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 fiscal reaction to the departures from long run trend in fiscal variables. According to that, in the period following the deviation, nearly half of the deviation is corrected.

They also test the stability of the fiscal reaction by running a state space version of the fiscal reaction involving the evolution of the reaction parameter over time. They set the fiscal reaction parameter as a random walk and let the other variables to be constant. According to estimation results, output gap parameter is once again negative indicating counter cyclical fiscal policy as in the case of former estimations in the paper. Up to 70s, the reaction parameter remains below zero consistently. According to the authors, the negative real interest rates during the period facilitated the debt management and therefore the government muted the fiscal reactions as they were in a way not needed. Since 1970s, the parameter rises continuously which indicates stronger fiscal reaction. The authors attribute this improvement in the indicator to rising real interest rate in the economy which requires stronger reaction to trim the excessive upward movements in the debt/GDP ratio. They claim that despite the fact that the snowball effect turned negative recently and alleviates the implementation of the debt management, the fiscal reaction is still strong in South

Africa. Favourable snowball effect coupled with strong fiscal reaction coefficient gave rise to substantial decline in the public debt to GDP ratio. Throughout a large portion of modern history of South Africa, the fiscal policies have shown remarkable degree of responsiveness to upward movements in public debt sufficiently to preserve sustainability. Despite the fact that the 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 variance in the nature of public debt management. Their methodology is based on Celasun et al (2006) which was discussed above. 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 GDP which are needed for fan-chart construction. They repeat the bootstrapped simulation for 1000 thousand times and using HP filter, and fed the fiscal reaction function with these simulated values so as 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 debt/GDP ratio. However, this reaction exhibits time-variance 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 very unlikely that future trajectory of the public debt will be explosive in South Africa. However, the future pathway of the public debt will be determined by the choice the government makes between stabilising debt and stabilising output.

Mauro et al. (2013) construct a panel data version of 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 fiscal reactions of the government.

Weichenrieder and Zimmer (2013) estimates a panel version of the Bohn (1998) approach on selected Eurozone countries to test whether the Euro membership has reduced the magnitude of the fiscal response coefficient compared to pre-euro era. Their data set covers 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 as 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 are able to determine the required level of 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 the fiscal policy of Kenya leading to the conclusion that the public debt in Kenya is not sustainable. He proposes long run fiscal adjustments to avoid serious threats to fiscal sustainability.

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

Nguyen et al. (2016) runs 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. Their aim is 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 but 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. In fact, this paper is a prominent example for proving the inadequacy of unit root tests and time invariant models to test the sustainability of public debt. The unit root analysis in this paper imply sustainability of public debt whereas the sustainability is refuted by time-varying fiscal reaction function model.

Arsić and Nojković (2016) analyse the public debt and primary balance nexus in Serbia before and during the economic crisis. The results of their fiscal reaction function imply that the fiscal efforts in Serbia were insufficient to revert the debt back to its stable path. They conclude that the lack of persistence in their fiscal efforts imply fiscal fatigue. They also state that when compared to the other countries in Europe, the strength of Serbian government to run fiscal efforts 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 for their analysis. Their time-varying results indicate that the corrective efforts of the government declines 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 convey 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 high-income gap and high levels of debt/GDP ratio. 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 the expansionary fiscal policies in Kenya, 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.

Obviously, there is a vast empirical literature on the fiscal reaction function, however due to space limitations we included only selected papers in this section. The main takeaway of this section is that, the public debt sustainability analysis based on fiscal reaction function is an active topic in the literature and the results as well as model variations are country specific. However, the Turkish literature on the fiscal reaction function and on its time-varying variants is reasonably unexplored. To reconcile our work with the literature, we can state that our thesis contributes to the literature by estimating a time-varying parameter version of fiscal reaction function with the longest annual data set ever used for investigating the public debt sustainability in Turkey by monitoring the evolution of fiscal response to debt dynamics from 1970 to 2017.

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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 the 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 the findings of the empirical estimations are evaluated to bring in a verdict about the sustainability of the public debt in Turkey.

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 70s which gradually lost their political influence during early 70s. The fundamental policies used in those plans included trade restrictions, investments on 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 and in the rest of the decade, the country suffered from severe economic contraction.

The post 70s era of Turkish economic history was largely shaped by IMF financial guidance and impetus, whilst in the pre-1977 era of the decade, Turkey had current account surpluses and high economic growth. There were, however, some discontinuities in this overoptimistic environment especially caused by international economic events. One of those impairing events was obviously the fourfold rise in the 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 no sufficient debt relief was provided by the international community, the rescheduling caused a further increase in debt stock through 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 external and internal malfunctionalities, the current account surplus was depleted and the government found itself in a position of extreme need for borrowing. This is when the concerns about the sustainability of debt embarked in Turkey. The debt profile was shaped largely by short term external borrowing which was obviously harder for the country to rollover (Celasun & Rodrik, 1989, p. 196).

For the third time in the history, Turkey implemented foreign exchange stringency in 1978. The foreign lenders impelled 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, debt crisis became inevitable for the country. The consequences of these unpleasant developments in the economy were mounting inflation and severe shortage of foreign exchange. Hence, unfavourable external environment, inappropriate maturity structure of public debt and malfunctioning policies gave rise to the debt crisis in the late 70s. It can be noted that the debt sustainability problems in Turkey originally started after the first oil shock rather than the second one despite optimistic environment appeared between the two. Apparently, the adverse international issues and flawed fiscal and economic policies led to the debt crisis gradually over this period in the country. The premature debt crisis in mid-1970s is effectively a postponed crisis characterized by short-term debt structure of mid-1970s. Such a strategy is inherently

destabilising for the economy and 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 turned out to be a depreciation of local currency which exacerbated the debt crisis even further. The situation was in fact a quasi-Ponzi scheme in that the sustainability of the borrowing strategy relied solely on the willingness of the foreign lenders in pursuing interest in financing the country. However, obviously the continuum of the influx of foreign financial resources to the country under those circumstances was very unlikely and 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. Also, the fiscal and economic policies were of little help for recovery. However, those stabilisation programmes and the efforts by the government were not sufficient for recovery in the economy (Celasun & Rodrik, 1989, p. 197). Besides, due to insufficient performance of the economy, those agreements were cancelled and another agreement was signed in 1980. 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 either. The undertaken policy measures were either too weak, or too late to successfully react to the deteriorating public debt conditions. Apparently, the depreciating effects of high interest rates dwarfed the positive effects of already low levels of growth and the fiscal reaction parameter. In addition, 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 24th of January 1980, Turkey embarked on a stabilisation programme which 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 the economic management. From then on, in most aspects of the economy, the decision was left to the market forces by means of

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 as well as 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 characteristic traits of the programme included; positive real interest rate to promote savings, export promotion, incentives for foreign investors, elimination of interest rate ceilings and implementation of floating exchange rate regime. During the subsequent years, the fruitful outcomes of the programme appeared in the economy, and economic growth mounted dramatically along with the positive atmosphere regarding exports and investment. However, noncommitment by the government to implement the programme properly 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). Despite the fact that there were some discontinuities in terms of economic stability, during the first five years of implementation, the economic indicators including growth improved remarkably 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 is the disciplined management in the first half of the decade which had 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 mid-80s. However, it should be noted that a sizeable debt relief was provided by the international community and new sources of financing became available which alleviated the economic conditions. As an outcome of the financial liberalization, the private banks were allowed to borrow in the international market and also the foreign banks were given the permission to participate in the financial transactions in Turkey. However, the debt relief by international financial institutions ended in 1984 which raised the 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 a 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 by this programme and not surprisingly the export-oriented growth programme came to an end in 1989 and a new set of liberalisation policies put into practice which were more liberal in nature than the predecessors. 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 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 to 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, appreciating 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 of time 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 on high interest rates. The social expenditures such as education and health had to be suspended due to budgeting constraints, therefore in the social level the welfare of the society fell dramatically. The 90s in fact can be thought of as a combination of short growth periods which are 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 which also contributed to the unpleasant portrait of the economic conditions. Besides, the Asian and Russian crises in late 90s had contagious effects on the already worsened conditions in the economy.

The 90s was largely characterized by 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 fiscal outlook of the country during the decade. The public sector financing needs increased from 10% to 15% at the end of the decade and the major determinants of such a remarkable public sector financing needs in the country were large duty losses and 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 90s, the budget revenues and expenditures increased at different speeds which also increased the level of indebtedness of the country. 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. In addition, 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).

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

Between 2000-2004, the magnitude of the public sector financing needs was to large extent determined by the social security deficits and fluctuating manner of these financing needs was an important indicator for the lack of long-term vision in the fiscal management during this period. Consequently, the sustainability of both fiscal stance and public services were threatened by the indicated short-sighted fiscal measures. Also, the restructuring of banking system during the economic crisis brought about a substantial increase in the financing needs leading to 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, and the conditions got so worse that a bigger intervention turned out to be inevitable for the economy. In an attempt to stabilise the economy, in 1998, a widespread disinflation programme was launched by the authorities. However, two major consecutive 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 intention, to facilitate the debt stock reduction by means of primary surplus generation in the following years. However, in less than a year, another serious financial crisis hit the economy in November 2000. As a consequence of this crisis, the primary balance targets set by the previous programme were updated to higher levels (from 3.7 to 6.5) and additional letter of intentions were submitted following the implementation of "Transition to Strong Economy Programme". Nevertheless, during 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 (Emil & Yılmaz, 2003, p. 22).

During early 2000s, Turkey performed remarkably well in terms of primary balance generation, however, the primary balance target set by letter of intentions were to large extent achieved by higher income generation rather than reductions in public spending. Since the tax base was not sufficiently large 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 ratio of the indirect taxes to the levels as high as 66.9 %. Along with the savings deficits in those years, the disposable income in the consolidated budget appeared to be negative 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 largely by worsened distribution of tax burden among the society (Emil & Yılmaz, 2003, p. 25).

Another distinguishing feature of the programme was the share of one-shot taxes levied particularly to cover the expenses aroused due to the earthquakes took place in 1999. The existence of such immediate income generation tools effectively proves that the quality of the income generation procedure of the programme was rather weak since no profound tax system reform was established within the postulates of the programme. Despite the fact that 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 and 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 where to large extent based on new and immediate income generation rather than expenditure adjustments and sound reforms in fiscal management. Failing to apply proper rationing and partitioning in terms of expenditure design, the government was essentially prevented from using public spending as an important policy tool during this period. In other words, the IMF programme in 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 gave also rise to a dilemma between the profound reforms and the short-term fiscal policy concerns for the policy makers which was to large extent 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 the implementation of such a fiscal reform was the absence of 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 had largely been based on 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 and 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 the financial assistance worth of 20.4 billion dollars, 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 the state-owned enterprises and reduce the involvement of the government 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 primary purpose of the agreement was to minimize the repressive effects of fiscal stance on the economy and the primary balance was the main 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 Financial Management and Control Law enacted in 2003 was one of the prominent steps taken to renovate the budgeting legislation concerning all segments of the government.

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 foreign exchange market. As the price of TL was being determined in the free market, the excessive flow of arbitrage seeking foreign capital caused a remarkable appreciation in TL. The programme designers believed that the proper implementation of the programme would improve the credibility of the country which in turn would facilitate the recovery by reducing risk premium and borrowing costs. Such a facilitation was affiliated with the program intensively, and consequently, the fiscal sustainability became one of the theoretical bases of the programme. In order to achieve this target, Turkey signed another stand-by agreement with IMF to prolong the promising environment generated by the fiscal discipline which appeared as a result of adherence to the IMF programme.

The absence of such a well-established fiscal discipline in 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 and heightening the pressure on the financial markets caused interest rates to rise. Higher interest rates eventually gave rise to even higher amount of debt stock through snowball effect. For this reason, the inevitable and primarily focused policy of the IMF programme was a transition to a 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 and the belated fiscal performance caused a deferral in the provision of crucial public goods

along with an overall deterioration in the economic status of the country. Those worsened economic conditions were the grounds for the implementation of additional stand-by agreements during early 2000s (Yılmaz, 2007, p. 5).

After the general elections in 2002, the single party government, despite some initial hesitation, declared that it will make a binding commitment to the IMF programme with strong emphasis on the primary balance generation. Following the commence of the programme, 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 were to large extent ignored by the authorities due largely to above mentioned dilemma between immediate needs of the society and programme reforms. Also, preserving the level of the performance in primary balance generation at sustainable levels was also quite challenging for the government since it required substantial amount of sacrifice in terms of fiscal space over a long period of time which could be very hazardous for a developing country like Turkey.

Unlike many other countries benefiting from IMF programmes, the measures for primary balance generation in Turkey were to large extent based on revenues rather than expenditures. Around 70 percent of the total fiscal adjustments were based on revenue generation, whereas only 30 percent was devoted to spending cuts and expenditure tightening. In other words, the above-mentioned shift 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 measures during early 2000s were one-shot adjustments whose effects are short-termed and not sustainable. Therefore, despite the fact that the programme targets were somehow met by the government,

the quality and the sustainability of those adjustments were obscured by the structure of adjustments (Yılmaz, 2007, p. 12).

Until the 2008 global crisis, Turkey performed remarkably well in reducing inflation, increasing growth and generating 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 as the real interest rate remained competitively high in Turkey throughout the period. Also, despite the fact that the primary balance performance was quite remarkable during this period, the short-sighted nature of the implemented adjustments led to heightened tax burdens in the economy and 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 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 2% of the GDP 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, some tax rates were increased and also scope of some taxes were enlarged. all of these alterations had impairing effects on the real economy particularly on the production and legal employment. Consequently, the cost of new employment and production rose remarkably compared to late 90s which created a disincentive for the private sector (Yılmaz, 2007, p. 23).

Despite occasional downward swings, throughout 2000s, the real interest rate remained higher than many developing countries which facilitated the boost in economic performance. As a result of the overvalued TL, Turkey faced an import boom which deteriorated the current account balance. The expansion of current account deficit coupled with decline in savings led to a gradual decline in the performance after the 2008 financial crisis. During the six-year implementation period of the IMF programme, 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 fiscal stimulus by the government brought it back to positive levels only 2010 onwards (Acemoğlu & Üçer, 2015, p. 10). Despite prolonged era of the growth, the country could not keep up with other developing countries in terms of economic performance largely due to the persistence of high inflation rate.

In addition to the economic developments, during 2010s several political events from several sources also affected the economy including 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 economy. However, except for the recent severe depreciation of TL against other currencies, the overall performance of the country was acceptable as far as the economic indicators were concerned. However, it is clear that in the recent years the financial resources in the international market are not as accessible as they used to be in 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. Despite the fact that debt/GDP ratio keeps remaining below the levels required by Maastricht criteria, the vulnerability of the private sector has surged dramatically as a result of the volatile exchange rate movements. Construction of large infrastructure projects which are financed within contingent liability schemes appear to be another source of risk for the public finances of the country since there is a potentially high risk of contingent payment through treasury guarantees. Purchase guarantees on those projects has the possibility of bringing extra burden on the budget in the near future which could impair the seemingly stable debt/GDP ratio.

3.1.2 Data Set

Having 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 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 IMF, namely IMF Financial Statistics Database, and IMF Historical Public Debt Database. The rest of the variables were retrieved from World Development Indicators Database of World Bank. The longest interest rate series available was the deposit rate which covers the 1986-2017 period. For the 1970-1985 subperiod 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 percent 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 from the series and the difference was scaled with the potential output and the result was multiplied the result with 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 to calculate the output gap as indicated in Burger et al. (2012)[4].

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 a sound scrutiny of public debt sustainability.

Primary Balance/GDP

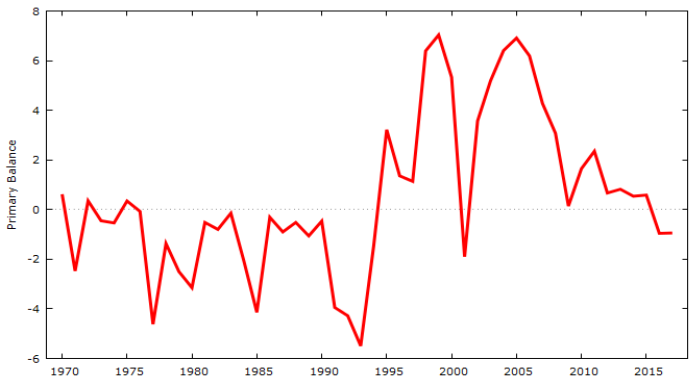
Figure 9 below plots the primary balance/GDP ratio over the estimation period. As it is clearly illustrated on the graph, until mid-90s, the primary balance was almost every year in deficit. This is obviously an important reason for the financial crises in 90s and early 2000s. During the period before 90s, there are remarkable fluctuations exhibiting short periods of improvements however, despite these occasional improvements, primary balance was negative on a continuous basis until mid-90s. Obviously, perpetual negative primary balance is a clear violation of the transversality condition and is an important sign for unsustainability in public finances.

The data plot of primary balance below can be partitioned into two subperiods. The first period until mid-90s is to large extent dominated by negative primary balances whereas the second segment, from mid-90s till late 2010s, is largely characterized by positive primary balances. During the first subperiod, 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 short-termed maturity structure of the public debt brought about negative primary balances in this segment of the data set. After 90s, a positive primary balance was an important tenet of the IMF programmes and the government was pinned down by the IMF

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

agreements to generate positive primary balances on a continuous basis. With the exception of 2001, Turkey managed to run primary surpluses in the post-1994 section of the data which is a good indicator for the existence of efforts by the government 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 impelling 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 the 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

The Table 1below 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 post-1994 period, and in deficit during pre-1994 period. The wide ranges during late 90s and early 2000s imply that fiscal performance fluctuated considerably during these years. The 1994 and 2001 are the crisis years therefore the intervals containing these years have the largest ranges because during the crisis the primary balance hits remarkably low levels which are followed by rapid improvements as an outcome of IMF interventions. Also, the relatively large range after 2006 indicates a gradual decay in the primary balance performance of the economy.

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

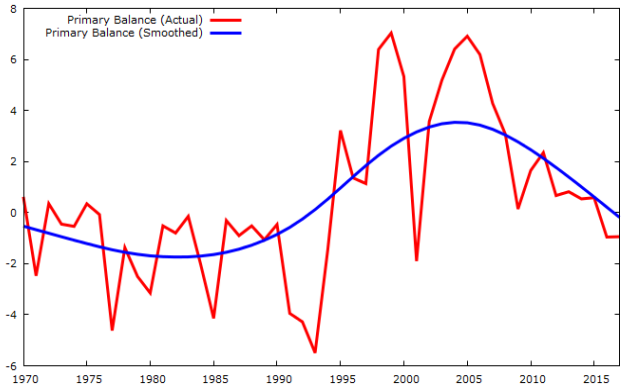
Source: Own Calculations

Besides, the IMF backed programme after 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 major tenet of the IMF programme and the proper way of reducing debt is to run primary balances on a continuous basis. Turning back to the Figure 9 it can be seen that the primary balance plummets in 2001 but in just one-year time increases to unprecedented levels and remains in those levels for several consecutive years. Nevertheless, in the recent years it is far from its past performance with the average of 0.11 percent.

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 primary balance throughout the years in the sample. The red line on the graph is devoted to real data while the blue 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 primary balance appearing as a result of cyclical events and automatic stabilizers.

Figure 1 Structural Decomposition of Primary Balance



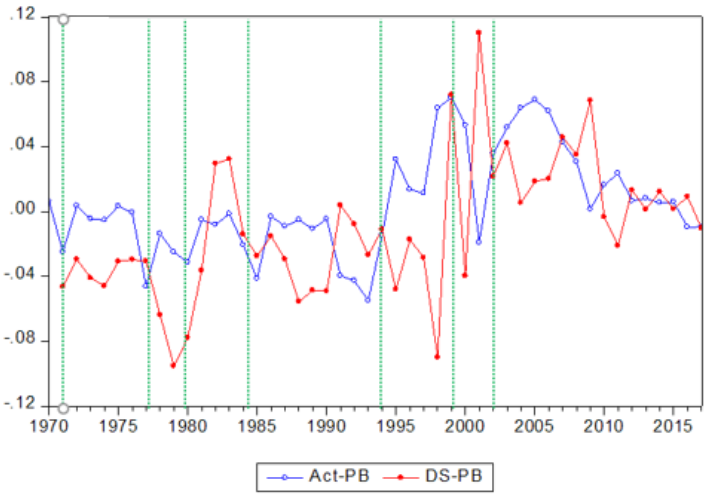
Source: Own calculations

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 existence of the fiscal responses by the government to reduce the debt level back to stable levels under the supervision of IMF. However, during the pre-crises episodes of early 90s the partitioning is vice versa or the two components are seemingly on a par with each other indicating lower control of the government on the fiscal policy compared to post-2001 era. Figure 10 also clearly shows that during late 90s and early 2000s the government managed to raise primary surpluses way above its long-term trend as an outcome of the IMF programme but in the post-2010 era the downward trend in the primary balance is so apparent as well. This can be interpreted as an indicator of diminishing fiscal strength for preserving the public debt sustainability in the country.

Furthermore, the figure below illustrates how the actual primary balance realizations measure up against the debt stabilising primary balance level throughout the estimation period. Recalling from the first chapter, the debt stabilising primary balance satisfies $\Delta d_t = 0$ condition and hinges on several factors such as level of public debt, availability of other tools of debt reduction and also the real interest rate and growth rate differential. Thus, comparing this hypothetical level of primary balance with the actual primary balance realizations

reveal remarkable insights about the performance of the government in debt management.

Figure 11 Debt Stabilising Primary Balance vs Actual Primary Balance



To calculate 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 red line depicts the debt stabilising primary balance which is calculated by Equation (11) and the blue one represents the actual primary balance generated by the government. Also, the dotted green lines on the graph represent the years in which a standby agreement with IMF was signed. Seven IMF agreements are pointed 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 which indicates that only a few times in the history, the required primary balance was just equal to the actual primary balance. Another point to consider is that, during the economic crises, the red line is always above the blue line indicating a poor performance in terms of primary balance reciprocations. Also, each IMF agreement is followed by episodes in which the actual level of primary balance is larger than required level as expected. The post-crises episodes, for instance, where the blue line is remarkably above the red line such as 90s or early 2000s points out to the governments' commitment to the IMF programmes which in a way impelled the government to generate large primary balances. Besides, in

the last ten years, with the exception of 2008, it appears that the red line is either slightly above the blue line or the two lines intersect with each other which points out to a relatively sufficient performance. During the 2008 global economic crisis, however, there is a significant difference between the two values. The red line hits a value above the 0.06 level while the blue line has a value around 0.001 in 2008. It means that during the global economic crisis, the government needed to generate a surplus of 6 percent, but it suffered from a near primary deficit which is an obviously prominent sign of the insufficient performance figure of the government to respond to debt dynamics. It also shows how vulnerable the Turkish economy is to the 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 two lines was extremely large that the required level was around 11 percent while the real level was below zero which corresponds to a primary deficit. Also, the first half of the 90s is largely and not surprisingly characterized by remarkable differences between the actual and required levels of primary balance where the required level is continuously above the actual primary balance. In addition, as illustrated by the graph, the dotted green lines appear whenever the red line is above the blue line 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.

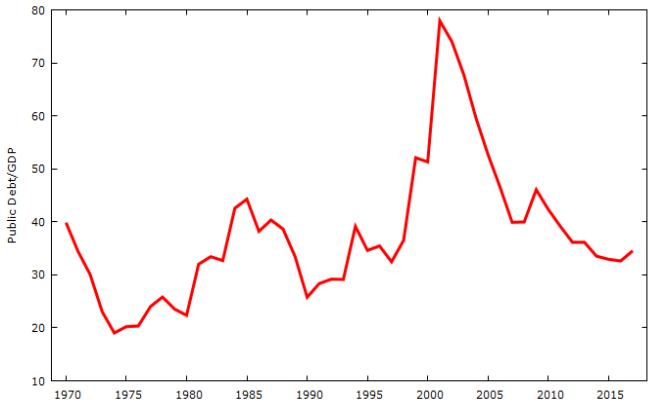
The Turkish economy was performing noticeably well until the petroleum crisis in late 70s, which can clearly be observed by examining the position of the lines during this period. However, the impairing effects of two petroleum crises can also be observed on the graph. In late 70s, the red line appears above the blue line for the first time after a period of seemingly good performance. After the crisis in late 70s, however, Turkey implemented an IMF backed recovery program and the military government exerted strong adherence to its implications. The outcome of this policy is also evidenced on the graph where the blue line is above the red line.

Nevertheless, in mid-80s the government lost the fiscal discipline which is also evidenced by the position of the red line being above the blue line during this era.

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. Actually, 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 20-50 percent band which is 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 on the Figure 12 below.

Figure 12 Public Debt (Percent of GDP)



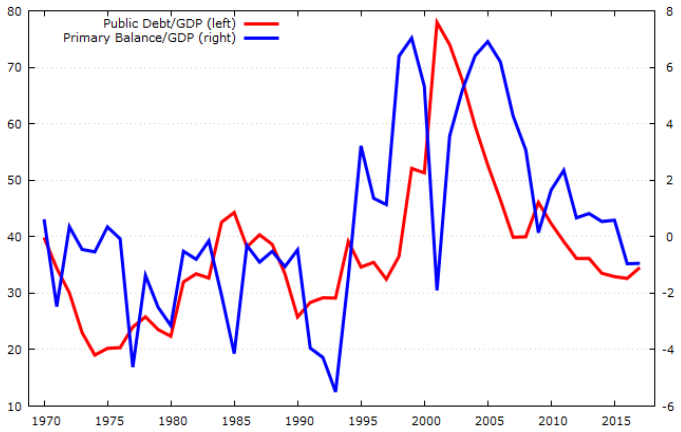
Source: IMF

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

Overlapping Figures 9 and 12 illustrates the subject more comprehensibly. On the Figure 13 below, the rising public debt in 90s coexists with primary deficits in the

economy. Also, through the end of the decade, primary balance improves but the public debt keeps rising which can be explained by low growth rate and short-term maturity of the public debt during the period. 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 as a shock on the level of debt. In theoretical perspective, the government has to reciprocate to this shock by raising the primary balances. The government indeed responded to this shock by raising the primary surplus but the driving force behind this reaction was the impelling force of the IMF programme. 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 time span.

Figure 13 Primary Balance and Public Debt Combined



Source: IMF

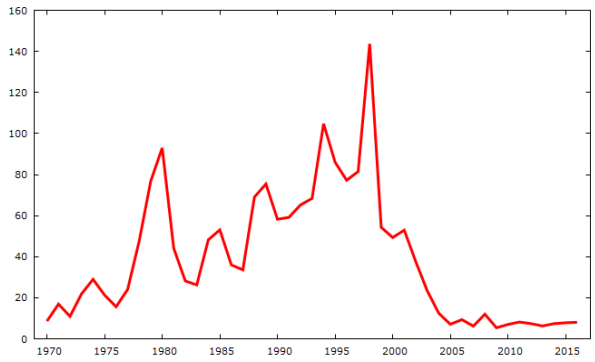
Nevertheless, the 2008 crisis proved that the economy is still vulnerable to external shocks despite seemingly stabilised debt ratio. Besides, the primary deficits and rising debt ratio in the last two years of the data raises concerns about the potential debt problems in the near future.

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 early 2000s, it has an upward trend despite some occasional downward movements, but after 2000s it is remarkably stable at seemingly low levels. The

disinflation programme of IMF during early 2000s appear to perform well in terms of reducing inflation. Inflation rate tops out during 1998 crisis and during this period, the government had lost control of debt management and currency devaluations, current account deficits, maturity structure of the public debt, contagious effects of Asian and Russian crises all contributed to instability in the overall economy which gave rise to a 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 the inflation since lower levels of real interest rate reduce the debt bill paid by the government. Thus, despite its deteriorating effects on the economy, the 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 the debt reduction in the short run, the negative real interest rate coupled with low growth rates indicate that debt level is not under the direct control of the government.

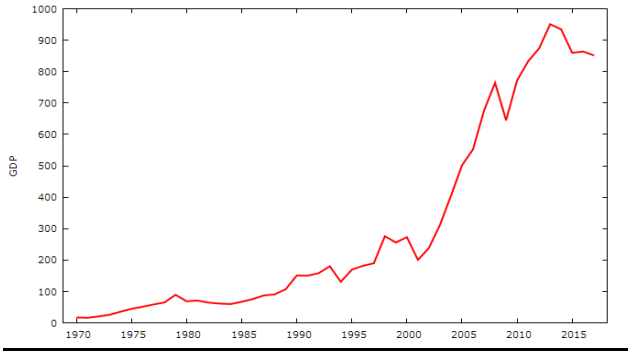
GDP

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 the value of this indicator 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 capacity to pay in the fiscal reaction function theory. According to that, higher level of GDP indicates higher level of fiscal space and thereby larger fiscal potential to keep public debt under control.

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

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



Source: World Development Indicators (World Bank)

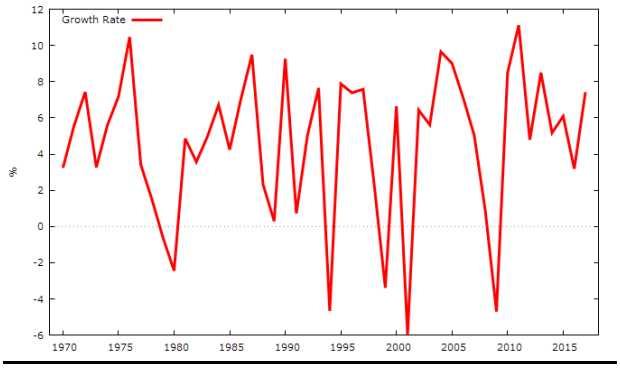
Seemingly low levels of GDP have been one of the most important economic problems in Turkey for the entire sample of 1970-2017. Restricting the governments' fiscal space, the low GDP levels were the major impelling force of rising public debt in Turkey especially during the pre-2000s period.

Growth Level

The growth rate for the estimation period is by far the most oscillating series in the data set 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 to reduce the public debt, the growth rate

needs to be sufficiently high. However, the Figure 16 illustrates that, 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)

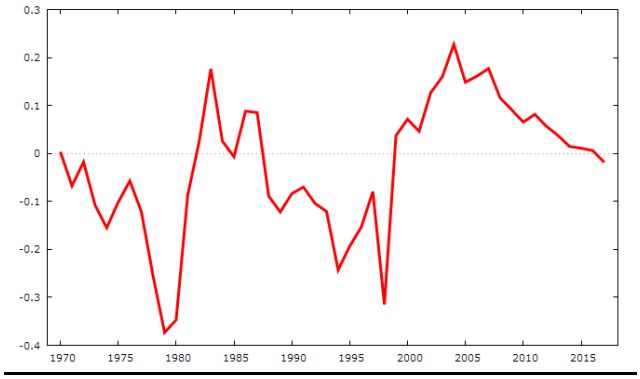
The Real Interest Rate

Along with the growth rate, the real interest rate is another major determinant of the explosiveness of the public debt. In developing countries, the real interest rate may be negative for long 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 70s, late 80s and entire 90s. The obvious reason for the prevalence of negativity in this parameter is the high level of inflation rate throughout the sample. Only during early 80s and early 2000s it reaches positive values impelled by stringent regulations of the IMF programmes.

One of the important tenets of the IMF programmes was the implementation of positive real interest rule to attract international funds to the country. Especially in early 2000s, after the severe economic crisis, this strategy facilitated the recovery from debt crisis as considerable amount of international funds flowed into the economy. Contrastingly, the negative levels of real interest rate exacerbated the debt management problems in 90s, as it was repelling the foreign investors from purchasing government bonds in large amounts. Failing to find sufficient long-term international funding, the government was oftentimes trapped in 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 70s for instance, the relatively low levels of debt/GDP ratio can be attributed to the alleviating effects of negative real interest rate. However, the emerging economies need to rollover the existing debt on a continuous basis. Thus, despite its beneficial aspects on reducing the burden of existing debt, the negative real interest rate has impeding effects on the debt servicing capability of the government by providing a disincentive for the foreign investors. Also, high inflation rates have devastating effects on the economy therefore in spite of its theoretical benefits, prevalence of high inflation rates and consequent negative real interest rates are in fact severely harmful for the economy. Moreover, the final noticeable point on the graph is that through the end of the estimation sample the value once again turns negative which is an unpleasant signal as far as the 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 since the

concept of sustainability is inherently a time-varying process which 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 type of estimations enhances the framework and improves the quality of the assessments of public debt sustainability. 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 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 with OLS incorporating multiple variables. They allow us to grasp the combined dynamics of a set of variables by including the lagged values of each endogenous variable. It is simply a generalization of single variable AR(p) model, to multiple variable case. Besides, the VAR models extend the framework by means of impulse response analyses and causality tests. For the analysis, a Vector Auto Regression model is set up to conduct impulse response analysis so as to test the response of primary balances to debt dynamics with the expectation of a presumable positive response to a shock in public debt. The VAR analysis also involves tests 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 so as to conclude if it is consistent with the postulates of fiscal reaction function theory. In this thesis, block exogeneity test was carried out to test the validity of the formulation of fiscal reaction function in Turkey given the indicated data set of macro variables.

Formally, framework for VARs can be described as follows;

If there are n variables, then;

$y_t = [y_{1,t}, y_{2,t} \dots y_{n,t}]'$ 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 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;

$$\left(I_n - G_1 L - G_2 L^2 - \cdots - G_p L^p\right) y_t = G_0 + e_t$$

$$G(L) y_t = G_0 + e_t$$

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 so as to avoid omitted variable bias. For this reason, 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 one of the very flexible and useful techniques for modelling time-varying coefficient models. The fundamental intuition behind the state space model is that, the impelling force behind the evolvement of the time series data at least partially 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 exogeneous factors into the model but those exogeneous factors need to be measurable for VAR setting. The state space model

in this sense outperforms the VAR models by incorporating the hidden factors into the model. The state space representation allows estimation of varying parameters in statistical models for each period of time.

Formally, a state space model of a Y_t procedure can be modelled as follows, [5].

$X_t \in R^v, Y_t \in R^w, \{F_t\}$ 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 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 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. Similar to other models such as OLS or Vector Auto Regression, state space model intends to find the best linear estimators as well. However, this method is interested

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

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 mostly set to equal to one.

$P_s X_t = A_0 Y_0 + A_1 Y_1 + \cdots + A_s Y_s$ $A_0, \ldots\ldots, A_s$ being a $v \times w$ 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 $pb_t = \left(\frac{r-g}{1+g}\right) d_{t-1}$.

In addition, according to many authors including Burger et al (2012) and Nguyen et al (2016), the magnitude of the β_3, i.e. the parameter indicating the effort by the authorities to stabilise debt, hinges on the $(r-g)/(1+g)$ ratio in the debt evolution dynamics. Therefore, if the real interest rate has been shown to be 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 so as to transform the fiscal reaction function into a time-varying format.

Formally, the fiscal reaction function can be transformed into 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 so as 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 in the thesis, 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 in 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 plots of the data series above, it can be concluded that throughout the sample, the primary balance oscillates within (-4, 4) percent band for a large part of the range, excluding some outliers. Also, the scale 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 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 clear on the data plot, excluding 2001, the debt/GDP ratio fluctuates within (20,50) percent band for most of the data range. Additionally, the dispersion turns back to its original shape in the post-outlier sections. This 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 exhibit geometric decay which indicate that shocks to the series are not permanent but temporary. This leads to mean reversion in the series 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, PACF of both series on the graphs falls abruptly after the first lag which can also be interpreted as a sign of stationarity. This 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

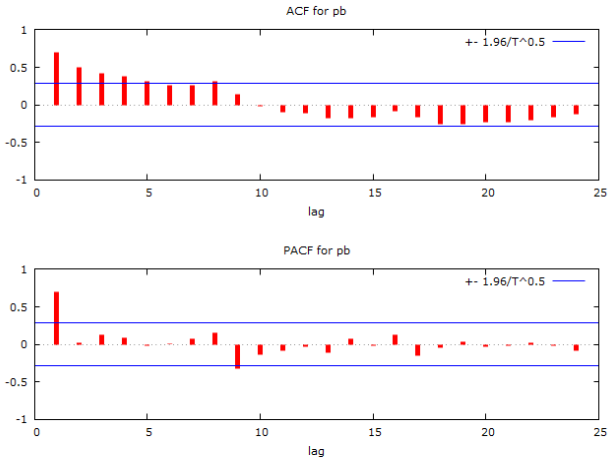
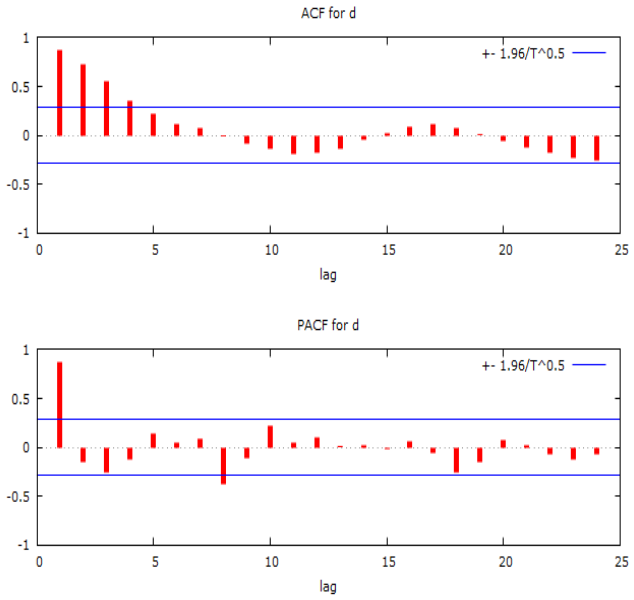


Figure 19 Correlogram of Public Debt



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, ADF test rejects the null hypothesis of unit root for primary balance at 10 % level. The PP test rejects the same hypothesis in all levels. Besides, the KPSS test cannot reject the stationarity hypothesis at 1 and 5 % levels and DFGLS test reject unit root hypothesis at all levels but ERS test only rejects at 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 unit root at 1 % and 5 % levels while ERS test rejects the null hypothesis of unit root in every level. Hence, for debt/GDP series, 3 out of 5 tests reveal results which are in favour of 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 which indicate stationarity whereas the other two tests indicate non-stationarity. Therefore, it is also safe to conclude that output gap is stationary as well. The final point to note here is that as mentioned earlier in the text, the formal stationarity tests are prone to be affected by the sample size. 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 with OLS are reliable and in addition, the Newey-West method was applied to obtain heteroskedasticity and autocorrelation corrected **(**HAC**)** standard errors.

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

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

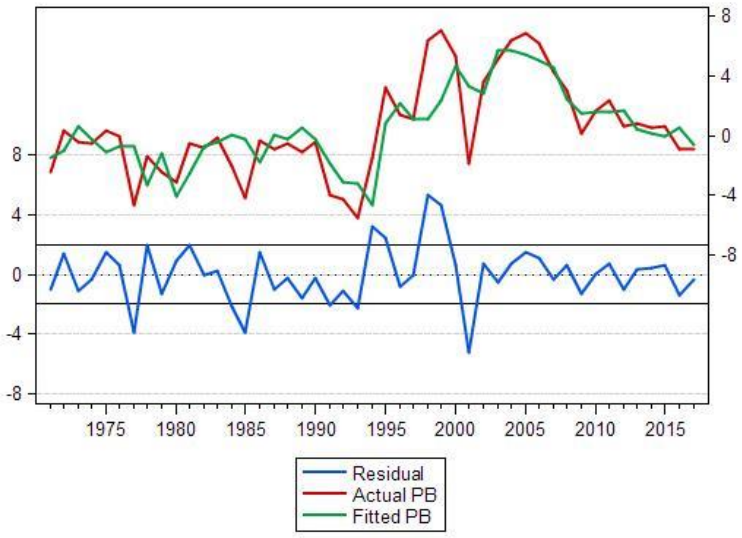
The OLS estimation of the equation reveals the following results with corresponding t statistics in parentheses;

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

(-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 serious disparities between the real primary balance and the fitted primary balance especially in 90s. and 80s. Also, partially in 2000s, the model fails to estimate the indicator properly. This is also 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 explanatory power of the model.

Besides, many authors including Bohn (1998) concur that constant coefficient models do not cover the real notion behind the fiscal reaction function theory since the fiscal reactions of the government are inherently time-varying. In other words, assuming a constant parameter of 0.059 for the entire sample is too stringent and not realistic. According to Bohn (1998), a positive fiscal reaction parameter is sufficient for a mean reverting debt profile but 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 possesses important insights about the fiscal performance of Turkey. The first point to make from the results above is that the sign of the β_3 coefficient 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 the sustainability of the public debt albeit in a narrow sense. Thus, based solely on this coefficient estimation, it can be concluded that, overall, public debt is sustainable.

Apart from fiscal reaction coefficient, the other coefficients also possess important insights about fiscal policy in Turkey. 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 fiscal behaviour of the government in one year is carried over to the next year. Presumably, this inertia only cuts off when the debt rises by some important 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 willingness of the government 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 the 60 % of the fiscal behaviour in one year into the next period. This clearly 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 compulsory transformations impelled by IMF, the government lacks the fiscal manoeuvrability when needed.

Furthermore, the negative coefficient of output gap indicates a procyclical fiscal policy by the government. In other words, during 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 sufficient amount of funds or they can only borrow at high interest rates. Hence, they cannot have primary deficits for long periods. In order to avoid borrowing which is very costly during recessions, they need to cut spending and raise taxes. On the other hand, during recovery, they can borrow under better conditions and increase the public spending.

According to the authors, the developing countries could instead accumulate reserves during recovery to ensure 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 could otherwise be wasted by the government. All these economic intuitions explain why we have a negative coefficient for 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 so as 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 debt/GDP ratio are influential in the formulation of the function so as to secure mean reversion in public debt.

According to him, the explanatory variables need to be formulated properly otherwise the model will suffer from omitted variable bias. According to calculations using the data set introduced above, the estimation results indeed implied omitted variable bias when the output gap is considered as an exogenous variable and 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 the main concern of this section 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[6]:

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

(-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 validity of the fiscal reaction function since it implies that the public debt is not a function of primary balance. Also, the coefficients are statistically significant in the first equation which is also suggestive of the fact that fiscal reaction function is valid for Turkey given the data set used.

Impulse-Response Analyses

Primary research area of this thesis is the fiscal response of the government to debt dynamics and the impulse-response analysis can provide additional evidence on the (non)existence of such a response in the economy. Also, along with the reaction of primary balance to the public debt, the analysis can be extended to include the response of the primary balance to shocks on other variables in the model as well. The output gap and lagged primary balance are also internal parts of the fiscal reaction function therefore, the response of primary balance to those variables are also integral components of our analysis.

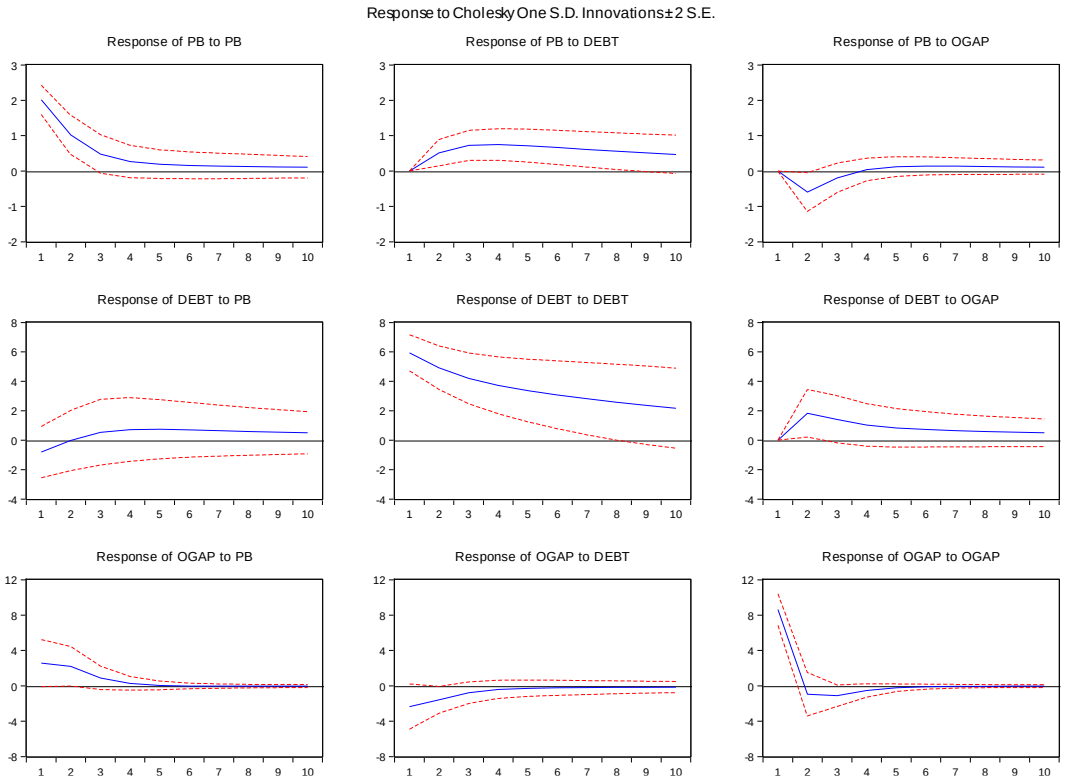
[6] See appendix for VAR inverse roots and residual tests results for the stability of VAR and OLS.

The Figure 21 below plots the impulse-response graphs all together. At first glance, it can be observed that that the stationarity of the variables is also evidenced by the graphs below as the auto-responses of each variable fade out gradually and they are not permanent. This is a clear sign for the stationarity of the variables. 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 earlier years. The government, to a large extent, tends to be conservative in amending the fiscal policy. In addition, the third 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, and 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 second graph in the first row. As it is clear from the illustration, the primary balance responds to a rise in public debt in a positive way. 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 a sustainability in the public debt in 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 but at the same time the empirical findings point out to 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 cause and effect relationship among two variables. The logic behind the exogeneity test is that if a variable is said to cause another variable when it gives rise to a 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 Granger causality test. If one variable Granger causes the other variable, the latter can be estimated more properly 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), the public debt is sustainable if it moves as a consequence of fiscal responses of the government. Hence, if the results of the test 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 it can be considered as a good indicator for the validity of fiscal reaction function theory. Depending on the estimation results, the causality can also be considered as an indicator of sustainability.

The results of this test are depicted on Table 3 below. The main research in this thesis focuses on the nexus between the public debt and primary balance. According to fiscal reaction theory, the primary balance has to respond to movements in the public debt so as to guarantee sustainability in the public debt. The test results of the equation where the primary balance is the dependent variable below are suggestive of the fact 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 and also the output gap needs to appear in the equation modelling the primary balance as well which is in line with the arguments of the Bohn (1998).

However, the test results of the second equation imply that primary balance can be excluded from the equation where the public debt is the dependent variable. This 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 used in this thesis.

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 a clear decomposition in the way Bohn (1998) describes. Also, the last two tests indicate that at 1% level the independent

variables of the public debt and output gap equations can jointly be excluded from the model which once 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 State Space Model Estimation Results

The time-invariant coefficient model estimations in the former section are suggestive of the fact that the 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 stronger requirements, time-varying properties should be incorporated into the framework and 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 for the entire sample indicates that the government is performing the same level of fiscal reaction each year which is extremely unrealistic. Thus, in this section, the fiscal reaction function is estimated in a time-varying formation by means of the state space model so as 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. Also, just as Burger et al. (2012) do, the constant term is omitted as it was statistically insignificant.

Formally;

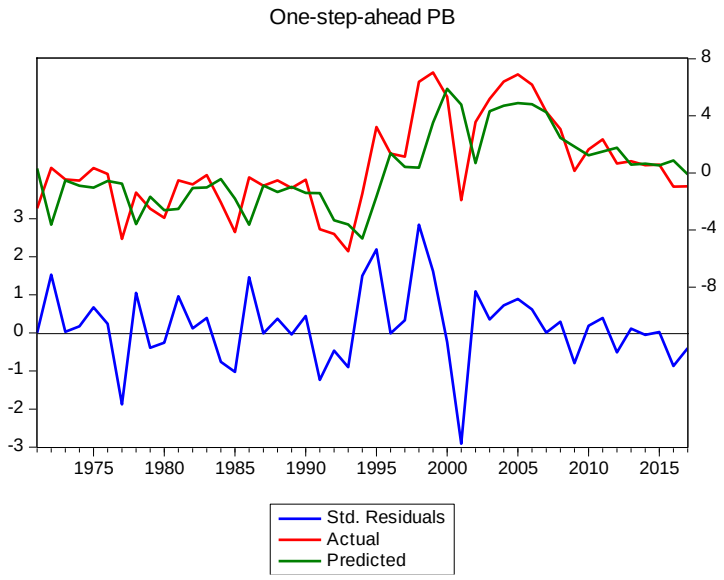
$$pb_t = \beta_2 pb_{t-1} + \beta_3 d_{t-1} + \beta_4 \hat{y}_{t-1} + \varepsilon_t$$

$$\beta_{3t} = \beta_{3(t-1)} + \eta_t\,,\ \ \eta_t\ \sim N(0, \sigma_\eta^2)$$

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 petroleum crisis in 70s, and the financial crises

of 1994, 1998 and 2001 the residuals are well behaved and noticeably stationary. Therefore, it is safe to comment on the estimation results.

Figure 22 Actual Fitted Residual (State Space)

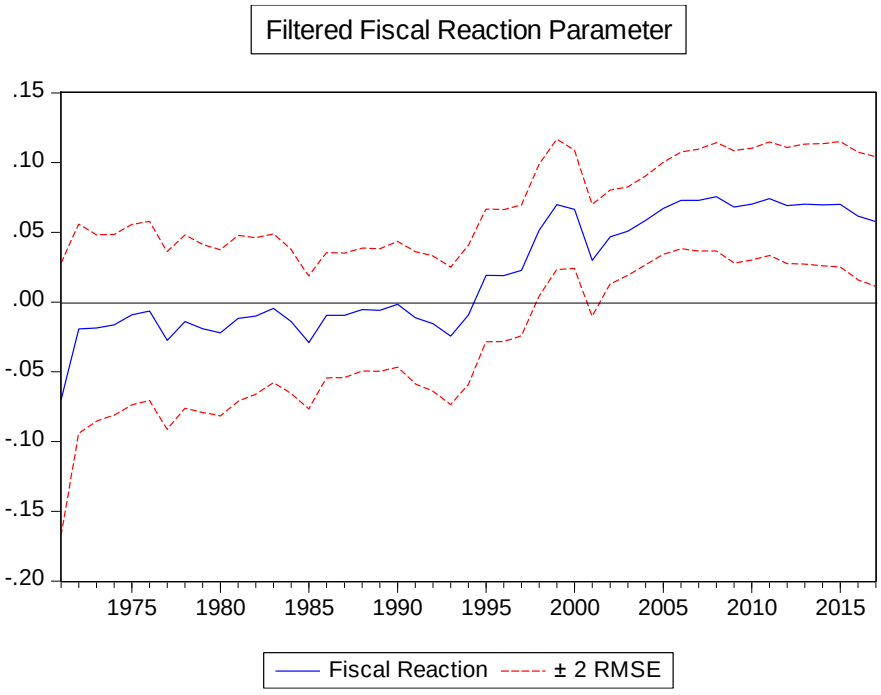


Compared to the OLS estimation, the state space version of the fiscal reaction function estimates the model more accurately and generates a better fit to the actual data. Also, the residuals in the state space setting oscillate in a narrower band in comparison to the OLS. In addition, the state space model outperforms the OLS model during the crisis periods as the gap between the green and the red lines are 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 constant coefficient setup.

The 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 and the time variance in the evolution of fiscal reaction is quite remarkable during the estimation period. Put differently, the fiscal reaction strength of the government is not constant but varies over time and largely influenced by outside conditions. Also, the first impression of the figure implies that the Bohn (2008) criterion for debt sustainability is not satisfied in Turkey as far as the totally positive 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 public finances in Turkey even though the positive portion is not far off. However, the confidence band is never completely below zero while it is almost always completely above zero after 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 on the Figure 23 above exhibits a clear time-variance but this variation is not random but is in harmony with the recent macroeconomic history of the country. As argued in the previous sections, the 1970-2000 part of the recent economic history of Turkey is shaped by several economic challenges such as international crises, funding shortages, inflation, etc. These economic conditions are reflected by the evolution of the parameter over time. The fiscal reaction coefficient is consistently below zero for almost every year until late 90s indicating the absence of fiscal reciprocation strength. Negative levels of fiscal reaction in this period is also suggestive of the fact that the debt/GDP ratio was not under the direct control of the government. 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 70s were sufficiently influential to lead to an upward movement in the reaction parameter to

bring it into positive territory. The liberal transformation in 80s appears to have a positive impact on the reaction parameter but this upward trend lasts only until mid-80s and disappears before the parameter reaches the positive zone.

Until 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 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 until 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 positive fiscal reaction, these factors brought about a dramatic rise in the public debt/GDP ratio through snowball effect. In the second half of the decade, the point estimation of the reaction parameter arrived at the positive region and also the real interest rate started falling which jointly gave rise to a partial decline in the public debt ratio. Apparently, in an attempt to gain control over the dynamics of public debt, Turkey has largely transformed its fiscal reaction policy in mid-90s. spurred by IMF agreements.

On 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 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 late 90s, the government has failed to systematically respond to debt fluctuations to design the outside economic conditions. It is clear that, the government pursued an active reaction policy following the IMF agreement in late 90s which impelled the government to control the public debt dynamics since no such reaction power existed until 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 point is worth noting from the parameter oscillation standpoint. Before the second half of the 90s, a considerably large portion of the band is below the zero level, whereas after late 90s the situation is just the opposite and the transition to the positivity is visible such that not only the point estimations but also the entire confidence band is above the zero level. Excluding the tiny deviation in 2001 crisis year, the partitioning between the two subperiods indicates a clear transformation in the fiscal policy in Turkey through time. Under the supervision of the IMF agreements, the governments performed strong adherence to fiscal discipline especially in early 2000s which generated sufficient capacity for fiscal reaction to reduce the already accumulated debt stock.

From late 90s onwards, the reaction parameter is consistently above zero and appears to be stabilised around the 0.05 level but unlike OLS results this result indicates that this value is obtained as outcome of a series of fiscal policy alterations and did not appear constantly for the entire sample. This indicates 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. However, as can be seen on the graph, before 90s the reaction parameter is far below this level which clearly points out to 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 the sustainability of the public debt 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 makes more insightful and meaningful arguments possible as far as the public debt sustainability is concerned.

As an outcome of this transformation, 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. Particularly in 1995, the fiscal reaction coefficient goes beyond zero level for the first time which

is a clear breakpoint in the fiscal strength enlargement process of late 90s. Starting with 1998, however, the parameter exhibits an unprecedented and systemic rise thanks to strong commitment by the government to the fiscal rules imposed by IMF programme albeit 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 level. In other words, the existence of systematic and positive fiscal reaction is evidenced by the location of confidence interval which is located in the positive territory as a whole.

The fiscal transformation on the graph is indeed a radical improvement in the parameter and not surprisingly corresponds to the point where 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. The 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 growth differential (the snowball effect) has accelerating effects on the public debt whereas the positive fiscal reaction potentially decelerates the public debt once exercised properly by the government. Hence, the movements in the public debt are to 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 snowball effect to the analysis. However, unlike developed countries, in developing countries, there are long periods of negative real interest rates and

negative growth. In other words, despite the fact that 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 postulations of the fiscal reaction theory, the real interest rate and 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 interest rate differential.

Unlike snowball effect, fiscal reaction does not appear automatically since it is a discretionary policy choice 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 on Figure 23 above. As argued above, the reaction parameter is not constant and there is an inherent time-variance in the fiscal reaction parameter and it reaches positive values only after harsh policy amendments. However, in spite of the differences in their characteristics, these two forces jointly determine the direction in which debt/GDP ratio will move in the next periods.

From 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 fiscal policies of the government. 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 this 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. Also, the negative snowball effect can exist in the case of a positive real interest rate and positive and large growth rate. The ultimate impact of negative snowball effect on the debt dynamics, however, hinges on the underlying conditions giving rise to it. Both conditions might seem favourable for the debt dynamics in the short run but the first case, where the real interest is negative and the growth rate is shallow, might have

deteriorating effects on both the fiscal management and also on overall economic performance. Since the real interest rate is negative, the government cannot rollover the existing debt or it can only do so in shorter maturities since negative levels of real interest rate 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 during this period the real interest rate and growth environment was suitable for debt reduction in Turkey.

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

Figure 24 Snowball Effect and Change in Public Debt

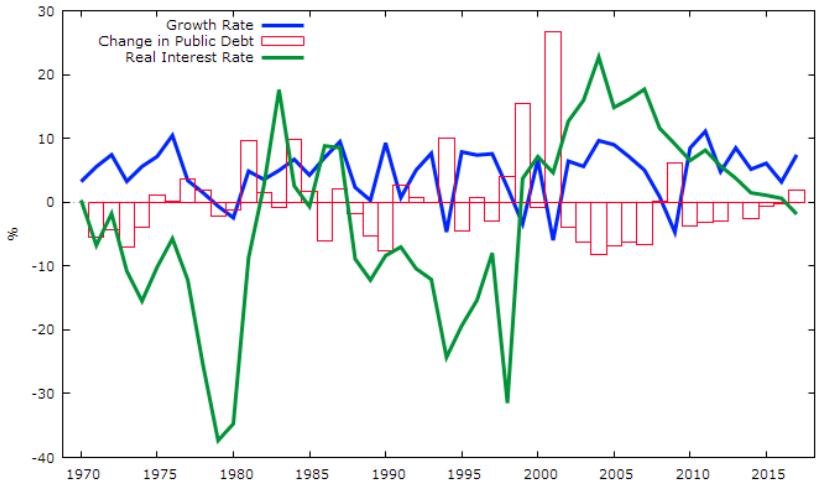


Figure above indicates that in early 2000s, the real interest rate remains steadily positive which was one of the tenets of the IMF stabilisation programme to attract international investors for financing the country. Combined with the positive growth rate in early 2000s, a positive albeit declining snowball effect appeared in the economy. Besides, as illustrated on Figure 23, the fiscal reaction coefficient was also positive during this period and 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 on 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 (on Figure 23) that despite 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 fiscal space needed to reduce existing debt level.

Nevertheless, right before the 2001 economic crisis, the change in debt/GDP ratio appears to be zero which indicates that the corrective impact of fiscal reaction was just equal to the snowball effect. During the crisis, however, the debt/GDP ratio climbs abruptly and tops out with a record high level which is largely due to rapid fall in growth rate and also to insufficient fiscal reaction. Despite the fact that the reaction parameter was still positive during this period, it was far from offsetting the impairing effects of lower growth rate. Clearly a much larger fiscal reaction was needed to avoid the rise in the debt/GDP ratio in this period. Going back to the Figure 23, it can be noted 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 IMF mentioned in the beginning of the chapter.

Until the global crisis in 2008 the economic conditions appear to be favourable from debt dynamics perspective with positive growth rate which reduces the denominator of the ratio; positive real interest rate which allows for the public debt rollover; and a positive fiscal reaction which trims the negative effects of positive real interest rate and prevents the public debt from being explosive. However, through the end of the estimation period, these favourable conditions seem to disappear since all three indicators are in a declining trend in 2010s. The debt/GDP level keeps falling until 2015 but afterwards 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 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 which can be observed on the 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, the recent economic history can be partitioned into two sub-periods in terms of fiscal management. In the period until late 90s, the government was unable to react positively to ongoing debt developments, but after late 90s it managed to respond positively to increasing debt albeit insufficiently during dire periods. One of the remarkable indicators of relevantly more profound fiscal policy in 2000s is how the increase in public debt during the 2008 global recession measures up against the change in 2001 crisis. Compared to 2001, the increase in the public debt was fourfold lower in 2009.

Unlike the economic slump in 2001, the 2009 crisis occurred when $r_t - g_t$ 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. This is what happened during the economic crisis in 2008.

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 bad ways of being solvent is the coexistence of negative snowball effect and negative fiscal reaction coefficient. From 1970 until 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 intertemporal solvency condition was by no means sustainable since it was based on perpetual negative snowball effect.

Recently, despite occasional declines, the reaction parameter is still positive in the last 5 years of the data set. Also, $r_t - g_t$ differential is following a very convenient trend for public debt sustainability since growth rate is bigger than the real interest rate while both indicators are positive. In fact, 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 the 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 and apparently will hit negative levels once again in the near future which is also worrisome for the sustainability of the public debt. 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 fiscal reaction strength of the government. Thus, although it is safe to conclude that the estimation results are indicative of a stabilisation in debt/GDP by means of 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 in a timely manner by proper policy alterations.

CONCLUSION

This thesis appraised public debt sustainability in Turkey in various levels of stringencies. In order to investigate the level of sturdiness of the public debt sustainability in Turkey, the fiscal reaction function designed by Burger et al. (2012) was adapted to 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 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. To assess public debt sustainability in various stringencies, the indicated fiscal reaction function was estimated in time-invariant setting with constant coefficients and also in a time-varying setup to monitor the evolution of the sustainability over the 1970-2017 period.

The estimations in the time-invariant coefficient setting are suggestive that there is a positive fiscal reaction in Turkey which guarantees public debt sustainability. Despite the fact that 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. Also, 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. In addition, block exogeneity test findings imply that the formulation of fiscal reaction function is valid for Turkey which backs the arguments about the sustainability of public debt in Turkey. Overall, these results from 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 the 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 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 although 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 whereas it appears in the positive sector as a whole during entire post 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 clearly be observed from the filtered state estimates of the fiscal reaction coefficient from 1970 until mid-90s. During this period, the reaction coefficient was consistently below zero which is indicative of unsustainable debt policy of the government 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 and the movements in the public debt were to large extent characterized by snowball effect and external factors which is clearly not sustainable in the long run.

The uncontrolled trajectory of the public debt during the first sub-period was obviously unsustainable which is evidenced by the long sequence of negative fiscal reaction parameters. However, after 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 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 2000s, especially after the 2001 crisis, the fiscal reaction coefficient remains consistently above zero even as a confidence band which explains the halving of debt/GDP ratio in just a few years after topping out in 2001. This period is characterized by 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 large extent based on temporary tax income generation rather than profound structural reforms in overall fiscal policy. For this reason, 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 2002 IMF agreement was positive real interest rate to provide incentive for the foreign investors. Also, growth rate was persistently positive during the same period. Normally, the positive real interest rate would worsen the debt position even further, but the impairing effects of positive real interest rate were trimmed by means of positive fiscal reactions during this period. As a result, debt/GDP ratio fell dramatically in a short period of time after 2002. During the post 2008 subsection, however, the joint forces of snowball effect and the fiscal reaction are in favour of debt management since the real interest rate, growth rate and fiscal reaction parameter are all in positive territory. Also, with the exception of early 2000s, growth rate is generally higher than the real interest rate which leads to negative snowball effect and consequently non-explosiveness is secured for the public debt. In other words, the early 2000s were characterized by deliberate positive snowball effect to attract the influx of foreign capital and positive fiscal reaction to trim the excessive movements in public debt arising due to 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 has alleviating effects for public debt

management in the short run, but it has deteriorating effects on the overall economy by providing a hindrance for attracting 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 the 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.

Otherwise speaking, the second sub-episode of 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 the recent years which clearly indicates that the government is losing its strength in using primary balance as a tool to stabilise 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 which will promote the likelihood of a potential debt crisis. In other words, the falling trajectory of the fiscal responses convey the country to an unsustainable debt position, therefore, the current negative trend in the fiscal reaction parameter should be reversed by improving primary balance so as to revert the unfavourable trend so as 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 fiscal reaction parameter is as important as achieving it through fiscal transformations like in early 2000s. Maintaining the current status of this parameter entails continuum of primary surpluses in the following years in order not lose control on the future course of public debt in the country. Despite the fact that 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 which are required to revert the fiscal reaction parameter back to positivity and their potential social costs are beyond the scope of this thesis but 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, from fiscal management perspective it is more appropriate to prefer the former over the latter. 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. In addition, political pressure on budgeting should be reduced to implement primary balance targeting through budgetary discipline as in the case of early 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. The snowball effect calculated for the analysis in this thesis, for instance, is a rough estimate because of data scarcities. Thus, a further research might bring in more precise data of the real interest rate on the government bonds and thereby implement more accurate calculations to obtain the exact differential between the snowball effect and the fiscal reaction parameter obtained through time-varying estimation for each year so as to assess public debt sustainability in Turkey in its most stringent form.

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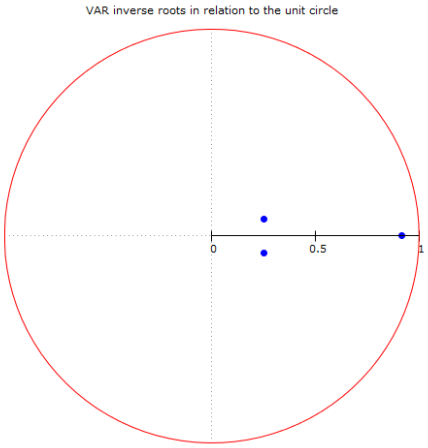
Appendix

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

```
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 gdp = 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

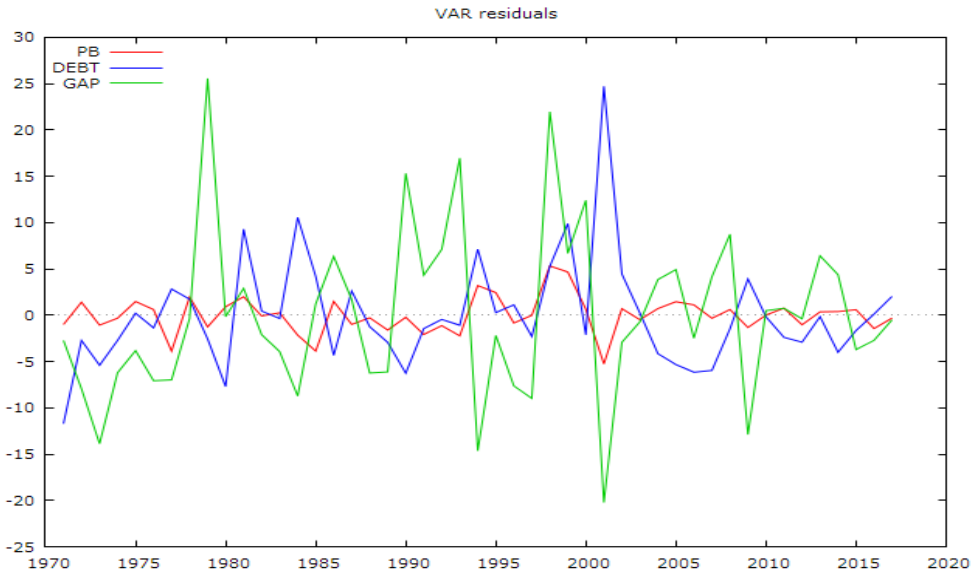
Probs from chi-square with 9 df.

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



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		

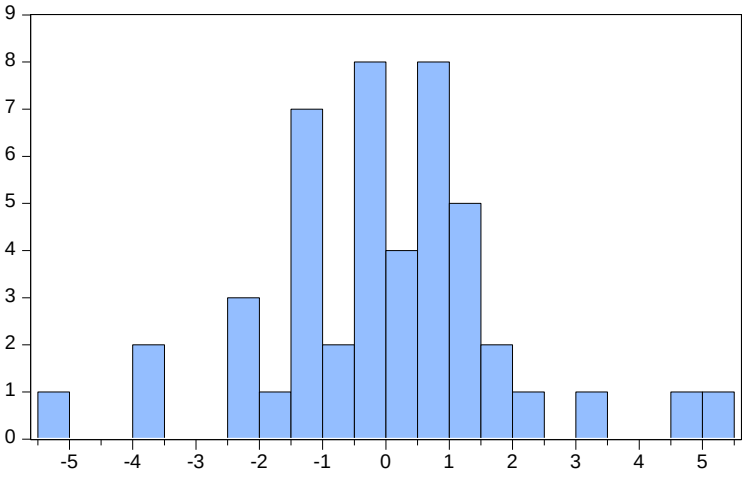
Breusch-Godfrey Serial Correlation LM Test:

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