UNIVERSITY UNION
BELGRADE BANKING ACADEMY
– FACULTY OF BANKING, INSURANCE AND FINANCE

ALEKSANDAR M. ZDRAVKOVIĆ

DETERMINANTS OF PUBLIC DEBT AND FISCAL SUSTAINABILITY

DOCTORAL DISSERTATION

Belgrade, 2019

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Date of defense:

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I hereby declare that this dissertation is my own original work and has not been submitted before to any institution for assessment purposes.

Further, I have acknowledged all sources used and have cited these in the reference section.

------------------------------ Belgrade, 01.10.2019.

Aleksandar Zdravković

Title: DETERMINANTS OF PUBLIC DEBT AND FISCAL SUSTAINABILITY

Abstract: The subject of this doctoral dissertation is an analysis of determinants of the public debt accumulation and assessment of fiscal sustainability in Serbia and selected peer countries. The main goal is empirical quantification of the relations between public debt dynamics and its determinants and subsequent assessment of fiscal sustainability conditions. The methodology of empirical research is based on three macroeconomic concepts: debt accumulation identity, intertemporal budget constraint and fiscal reaction function. The focus of empirical research is on econometric modeling of public debt dynamics with respect to fiscal and non-fiscal determinants and forward-looking simulations of the public indebtedness indicators.

The central part of the empirical research methodology is divided into four building blocks. The first methodological block is an exercise of debt accumulation decomposition to individual contributions of its determinants. The second block is a panel regression analysis that quantifies the impact of debt determinants (primary balance, real growth, inflation, real exchange rate, and interest rate) on the dynamics of actual and structural public indebtedness. The third block is a panel estimation of the reaction of fiscal policy stance to the debt accumulated in the past and cyclicality of economic output. Application of scenario analysis and stress testing to forward-looking simulations of the debt dynamics as a forth block completes research methodology.

The results of empirical research imply that all four hypotheses are proved. Results from the regression modeling of public indebtedness confirm the dynamics of the debt covariates with non-fiscal and fiscal variables. Descriptive analysis of debt decomposition and econometric modeling of indebtedness impose that debt-deficit adjustments and cyclically-adjusted primary balance as the fiscal variables are the most important contributors to public debt dynamics. Estimated results from the empirical modeling of the fiscal reaction function reveal that in the post-crisis period, the fiscal stance of the Emerging European Countries (EEC) positively responded to accumulated debt, confirming third hypothesis. Scenario analysis and Monte Carlo debt simulations indicate that accumulation of public debt would be profoundly accelerated if EEC countries did not interrupt practicing pro-cyclical fiscal policy behavior after the global crisis outbreak in support of fourth hypothesis validity.

Keywords: public debt, debt determinants, fiscal sustainability, fiscal reaction function, cost-risk analysis, panel regression, structural VAR, stochastic simulations

Scientific field: Economics

Narrow scientific field: Public Finance

Naslov: DETERMINANTE JAVNOG DUGA I FISKALNE ODRŽIVOSTI

Rezime: Predmet doktorske disertacije je analiza determinanti akumulacije duga i ocena fiskalne održivosti Srbije i uporedivih zemalja. Osnovni cilj istraživanja je empirijska kvantifikacija odnosa između dinamike javnog duga i njenih determinanti u kontekstu ocene ispunjenosti uslova fiskalne održivosti. Metodologija empirijskog istraživanja je izvedena na osnovu tri makroekonomska koncepta: jednačina akumulacije duga, inter-temporalno budžetskog ograničenja i funkcije fiskalne reakcije. Fokus empirijskog istraživanja je na ekonometrijskom modeliranju dinamike javnog duga kao funkcije fiskalnih i nefiskalnih determinanti i simuliranja budućih vrednosti indikatora javne zaduženosti.

Centralni deo metodologije empirijskog istraživanja se sastoji iz četiri celine. Prvu metodološku celinu čini dekompozicija akumulacije duga na doprinose pojedinačnih determinanti. Drugu celinu čini panel regresiona analiza kojom se kvantifikuju uticaji determinanti duga (primarnog bilansa, realnog rasta, inflacije, realnog deviznog kursa i kamatne stope) na dinamiku stvarne i strukturne zaduženosti. Treći blok obuhvata panel estimaciju reakcije odluka fiskalne politike na akumulirani dug u prošlosti i cikličnost ekonomskog autputa. Primena scenario analize i simulacije budućih vrednosti javnog duga kompletira istraživačku metodologiju.

Nalazi empirijskog istraživanja impliciraju da su sve četiri hipoteze u disertaciji dokazane. Rezultati regresionog modeliranja javne zaduženosti ukazuju na kovarijabilnost dinamike duga i fiskalnih i nefiskalnih determinanti. Deskriptivna analiza dekompozicije duga u kombinaciji sa ekonometrijskom modeliranjem zaduženosti potvrđuje da su usklađivanje duga i deficita i ciklično-prilagođeni primarni bilans, kao fiskalne varijable, najviše doprinosili akumulaciji javnog duga. Rezultati empirijskog modeliranja funkcije fiskalne reakcije evropskih zemalja u razvoju pokazuju da je u post-kriznom periodu postojalo pozitivno prilagođavanje odluka fiskalne politike nivoima akumuliranog duga. Scenario analiza i Monte Carlo simulacije impliciraju da bi u evropskim zemljama u razvoju akumulacija javnog duga bila značajno brža da nakon izbijanja globalne krize ove zemlje nisu prekinule sa praktikovanjem pro-ciklične fiskalne politike, u prilog validnosti četvrte hipoteze.

Ključne reči: javni dug, determinante duga, fiskalna održivost, funkcija fiskalne reakcije, analiza troškova pod rizikom, panel regresija, strukturni VAR, stohastičke simulacije

Naučna oblast: Ekonomija

Uža naučna oblast: Javne finansije

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1. INTRODUCTION

1.1 Subject and objectives of the research

The concept of fiscal and debt sustainability draws on the idea that public debt cannot keep on growing relative to national income since this would require governments to constantly increase taxes and reduce public spending. The public debt sustainability as the global issue in economic policy gains global importance after the outbreak of the global financial crisis, which triggered the Eurozone sovereign debt crisis. The financial crisis and subsequent recession have led to the rapid deterioration of government finances in many European countries. Self-reinforcing effect on the deficits, the higher interest rates and declines in the creditworthiness of sovereign issuers have reduced the sustainability of future debt dynamics. The escalating yield spreads in the Euro area in 2010 have underlined how suddenly these mechanisms can cut off a sovereign borrower from the capital markets, with notable examples of Greece and Ireland being enforced to look for financial assistance from the EU member states and the IMF. Regarding the average EU and Euro area, countries from central and eastern Europe recorded considerably lower level of debt-to-GDP ratio. However, due to the tricky growth prospective and rising deficits in the aftermath of the crisis, the European Commission launched the Excessive Deficit Procedure in all of the New Member states.

The widespread practice of inappropriate public debt management was mainly caused by the inadequate assessment of the public debt determinants' exposure to fiscal and macroeconomic risks. From the theoretical point of view, an increment of the gross public debt can be decomposed into two components: overall fiscal balance of the general government and debt-deficit adjustments, the latter reflecting sum of residual mismatches between stock and flow positions in government financial statements. Since the overall fiscal balance is the main driver of debt accumulation over time, analysis of its determinants and associated risks makes a crucial element of the fiscal sustainability assessment.

Decomposition of the fiscal balance to primary balance and interest payments on debt accumulated in the past is the first step toward analysis of the public debt determinants and fiscal sustainability assessment. As a difference between public revenues and primary public expenditures, primary balance is a result of the fiscal policy decision making and thus represents the measurement of the fiscal policy stance. Consequently, it is mainly exposed to the risks of economic fluctuations and non-credible public financial management. On the other side, interest payments are mainly exposed to the market risks of changes in interest and exchange rates, with respect to the public debt portfolio term and currency structure.

The subject of this work is a theoretical and methodological discussion on the relations between public dynamics, its determinants, and fiscal sustainability assessment, as well as empirical analysis of these relations based on a sample of countries consists of Serbia and seven peer countries. The objectives of the research can be systematized in two areas: analysis and quantification of the transmission channels from public debt determinant toward public debt dynamics, and the reaction of the fiscal policy stance to the dynamics of the debt and its determinants.

1.2 Research hypotheses

The most of the theoretical, methodological and empirical research in this work revolves around the issues relevant for testing the following set of hypotheses:

- H1: Dynamics of the public debt is correlated with change in non-fiscal and fiscal variables;
- H2: Dynamics of the public debt is more sensitive to the impact of fiscal than non-fiscal variables;
- H3: Fiscal sustainability is conditional to the positive response of the primary balance to change in public debt;
- H4: Pro-cyclical reaction of the fiscal stance to fluctuations of the economic activity jeopardizes fiscal sustainability.

1.3 Methodology

The methodology applied in this work consists of the following research methods:

- The desk research method applied in the systematization of the theoretical and methodological concepts and results from the existing empirical studies, aiming to argue relevance of the hypotheses and specification of the empirical research procedures;
- Methods of descriptive, comparative and correlation analysis to illustrate main stylized facts on dynamics of public debt and its determinants in the sample of selected countries from the Central and Eastern Europe;
- Methods of financial mathematics and portfolio analysis applied in the cost-risk analysis of the Serbian debt portfolio;

- Method of panel regression analysis applied in modeling of the public debt dynamics and fiscal reaction in the sample of selected countries from the Central and Eastern Europe;
- Methods of time series analysis (Unit root testing, Structural Vector Autoregression) applied in modeling and forecasting of the public debt determinants;
- Method of Monte Carlo stochastic simulations applied in probabilistic forecasting of the public debt dynamics;
- Method of scenario analysis and stress testing applied in the assessment of debt sensitivity to macroeconomic shocks.

1.4 Scientific contribution

The scientific contribution of this thesis reflects in a variety of aspects:

- It provides comprehensive and original systematization of the relevant theoretical concepts for the proper operationalization of the methodology for public debt forecasting and fiscal sustainability assessment;
- It makes links between public finance accounting standards and theoretical concepts of debt accumulation identity;
- Opposite to existing literature, this thesis methodologically approaches to the issues of public debt dynamics' analysis from the standpoints of both public debt portfolio management wherein gross borrowing requirements are key analytical input, and fiscal policymaking wherein net borrowing requirements are key analytical input;
- The novel methodological approach to the debt forecasting and fiscal sustainability assessment based on the structural indebtedness and fiscal policy stance is proposed;
- The practical methodological solution to the deterministic projections of the debt market determinants in the emerging economies with underdeveloped financial markets, such as Serbia, is proposed;
- It contributes to the rare existing studies that empirically examines the issues of debt accumulation and fiscal sustainability in emerging European countries;
- It underscores issues of econometric analysis of time series cross-section data (TSCD), that are usually neglected in similar empirical work;
- Lack of evidence on the out-of-sample performance of the stochastic simulations of public debt dynamics, being one of the most important drawbacks of the existing empirical literature, is addressed;
- Empirical results related to the identification of the country-specific characteristics of debt dynamics and fiscal policy stance, together with assessment of cross-

country patterns between debt determinants, gives the solid ground to policymakers that can be further utilized in the forward-looking analysis of the fiscal sustainability.

1.5 Structure of the work

The introductory chapter of this thesis depicts the research subject, objectives and hypotheses, respective methodological framework for empirical analysis and scientific contribution.

The second chapter provides a detailed discussion on the accounting metrics of the debt and informational content of the public debt statistics with respect to accounting standards and structure of the debt portfolio. The theoretical concept of the debt accumulation equation is introduced and then linked to the public finance accounting outcomes. Important distinctions are made between gross and net borrowing requirements, fiscal and non-fiscal determinants of the public debt, and transmission channels in which determinant affects debt dynamics are addressed. Eventually, scenario and stress testing as forms of debt sensitivity analysis are elaborated.

The third chapter deals with the concepts that constitute the fiscal sustainability framework. More specifically, it provides theoretical and operational grounds of the concepts of Cost-Risk modeling, intertemporal budget constraint and fiscal reaction function.

The fourth chapter gives a comprehensive overview of the relevant literature, systematized to cover separately theoretical and methodological findings on one side, and empirical research on the other. The shortcomings of the existing literature are briefly figured out.

The first segment of the fifth chapter presents a comparative analysis of public indebtedness and its determinants in selected EEC countries (including Serbia), as well as with the exercise of public debt decomposition to the non-fiscal and fiscal contributions. The second segment deals with the same issues but in formalized way, throughout econometric estimation of the debt determinants' impact on public debt dynamics.

The sixth chapter gives methodologies and empirical results of the forward-looking analysis grouped into three segments: forecasting of debt determinants, forecasting of costs and risks of debt, and forecasting of public debt dynamics with the associated econometric estimation of the fiscal reaction function. The empirical research has innovatively designed in form of out-of-sample analysis.

The conclusion chapter presents the most important findings of the work, their implications on fiscal policy and limitations of the existing research and recommendations for future work.

2 THEORETICAL AND METHODOLOGICAL FRAMEWORK OF THE PUBLIC DEBT DETERMINANTS' ANALYSIS

2.1 Public debt definition and statistics

The term "public debt" has been colloquially associated with all forms of the financial liabilities of the state authorities or the state-owned entities. In the strict statistical sense, a proper measurement of public debt has been an issue profoundly discussed by the academic community, international organizations and government authorities for years. Development of the System of National Accounts and the European System of Integrated Economic Accounts brought about much standardization in debt accounting in European countries and facilitated cross-country comparable debt reporting. In this section I discuss some issues on public debt measurement and statistics. The discussion revolves around a couple of important issues on available public debt statistics, including international accounting standards, delimitation of the government and public sector and reporting statistics on public debt value and structure.

2.1.1 Accounting standards

The first attempt to promote standardized measurement of economic indicators on the international level originates from the United Nations (UN) international accounting guidelines in 1947. A couple of years later, the UN Statistical Commission published the System of National Accounts (SNA), aiming to provide a comprehensive conceptual and accounting framework for macroeconomic reporting. Since introduction, the SNA has been well accepted by the government authorities worldwide and become basis of individual countries' national accounting, but also the central pillar of continuous efforts of the intergovernmental organizations aiming to achieve mutual standardization of accounting practices. The major advance toward this objective was achieved in 1993, when a new version of the SNA was released as the result of the mutual work of the United Nations, the IMF, the OECD, the World Bank and the European Commission (Eurostat) on harmonization of national accounting principles. Since this revision, the follow-up accounting frameworks, like European System of Accounting (ESA) of the EU or Government Finance Statistics (GFS) of the IMF, have been harmonized with the SNA. The same group of organizations in 2008 published the latest version of the SNA, being currently in place.

Apart from the SNA, other important manuals dealing with the issues of compiling debt statistics include ESA Manual on Government Deficit and Debt (MGDD) and Government Finance Statistics Manual (GFSM). The first edition of ESA MGDD was published in 1999, by the mutual efforts of Eurostat, European Commission (EC) and European Central Bank (ECB). It follows the ESA 95 conceptual framework, which after February 2000 has become legally binding for all EU member states. The main purpose of MGDD was to provide reliable and comparable statistics on government debt and deficits that can be further used for the evaluation of Maastricht criteria related to debt and deficit thresholds. The last edition of MGDD was published in 2014, and it is complementary with the newly adopted ESA 2010 accounting framework. The first edition of the IMF's GFSM was published in 1986. As stated in a preface, the primary purpose of the Manual is "*to provide a comprehensive conceptual and accounting framework suitable for analyzing and evaluating fiscal policy, especially the performance of the general government sector and the broader public sector of any country*". The third revision of GSFM published in 2014 is currently in place, harmonized with the SNA 2008.

2.1.2 Delimitation of the government and public sector

The terms "government debt" and "public debt" are often used interchangeably, as I do in this work (if the difference is not emphasized). However, according to prevailing international accounting rules, there is a clear separation between (general) government sector and the public sector, which is an important issue in explaining the scope of debt statistics compiled by the statistical offices.

One of the most important conceptual definition introduced by the SNA 1993 was delimitation of the resident institutional units into five mutually exclusive sectors: the non-financial corporations, the financial corporations, the general government sector, the non-profit institutions serving households and the households, which altogether make up the total national economy. This is particularly important from the point of measuring government and public debt since the clear delimitation of the government and public units is the first step toward debt statistics compiling. According to this definition, the general government sector consists of government institutional units, "*unique kinds of legal entities established by political processes that have legislative, judicial or executive authority over other institutional units within a given area*". In economic sense, the authority of the government unit reflects in power to enforce fundraising activities over other institutional units, while these funds are typically spent on providing services to community either free or at economically insignificant prices, or transfers to other institutional units for the purpose of income redistribution. More particularly, government units that match such definition are grouped into four subsectors: central government, state government, local government and social security funds. Social security funds are often considered, together with other budgetary and extrabudgetary users on the central level, as a part of central government, but can be alternatively grouped in separate subsectors, especially for the purpose of statistical reporting.

However, the government units are not the only ones that make up the public sector. According to the SNA, the public sector consists of the general government sector and subsectors of financial and non-financial public corporations, as illustrated in Figure 2.1 (IMF 2001, pp. 15). A corporation is defined as a public "*if a government unit, another public corporation, or some combination of government units and public corporations controls the entity, where control is defined as the ability to determine the general corporate policy of the corporation*" (SNA, 2009, pp. 71).

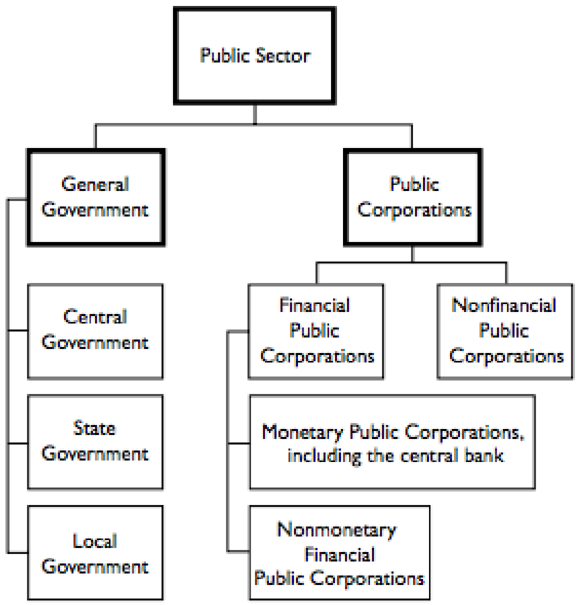

Figure 2.1: Definition of public sector
Source: *GFSM 2001, pp. 15*

In practice, it is not so trivial to distinguish public corporations from general government units. For that purpose, the SNA established a so-called "non-market rule". According to this rule, all the public units that are non-market producers ought to be classified in the general government sector. The SNA 93 introduced the concept of "economically significant prices", as a basic criterion to make a distinction between market and non-market producers: if producer charges economically significant prices to consumers, then it is considered to be market producer and *vice versa* (SNA 1993, paragraph 6.45 and 6.5). A price is considered as economically insignificant "*when it has little or no influence on how* *much the producer is prepared to supply and is expected to have only a marginal influence on the quantities demanded*" (EC, 2002, pp. 13). The ESA 95 introduced the "the 50% rule" as an additional benchmark for delimitation of public producers to public and general government units. This rule basically asserts that prices should be considered as economically significant if sales cover more than 50% of the production costs (EC 2002, pp. 14).

Serbian public finance institutional framework is mostly aligned with SNA and ESA provisions. The scope of the Serbian public sector was defined for the first time by The Law on Net Income Reduction for Public Sector Employees[1]. According to the provisions of this Law, the public sector in Serbia covers the following entities:

- Direct and indirect budget users of the Republic, autonomous province or local self-government;
- National Bank of Serbia;
- Public agencies founded by the Republic, autonomous province or local self-government in line with relevant legislation (including all regulatory and supervision institutions, commissions, funds, councils and other entities);
- All entities and organizations founded by the Republic, autonomous province or local self-government in line with relevant legislation;
- All public enterprises founded by the Republic, autonomous province or local self-government in line with relevant legislation, as well as entities founded by public enterprises;
- Legal persons controlled by the Republic, autonomous province or local self-government, either through more than 50% of ownership or more than 50% representatives in managing bodies.

Following the scheme in Figure 2.1 and public sector definition by The Law on Net Income Reduction for Public Sector Employees, the public sector in Serbia can be grouped in the following three categories:

1. Central government level:

- Direct users of the Republican budget: parliament, President's office, ministries, judiciary and other budget agencies;
- Indirect users of the Republican budget (courts, schools, etc);
- Mandatory social insurance funds: Pension Insurance Fund, Health Insurance Fund, Unemployment Fund and Military Health Fund.

[1] RS Official Gazette 108/13

2. General government level:

- Central government level;
- Extrabudgetary funds: PE Roads of Serbia and Koridori Ltd;
- Subnational governments: Autonomous Province of Vojvodina, local governments (cities and municipalities) and indirect budget users of local governments.

3. Public sector:

- General government level;
- National Bank of Serbia;
- Non-financial public corporations (such as Serbian Railroads, Serbiagas, etc);
- Depositary public corporations, other than the national bank (banks controlled by the government such as Komercijalna Banka);
- Other financial public corporations (such as Dunav Osiguranje).

While official public finance accounting and reporting in Serbia is based on the previous classification, it usually covers only central and general government level.

2.1.3 Definition of government debt statistics

According to the SNA, debt in the broadest sense is defined as "*all liabilities that require payment or payments of interest or principal by the debtor to the creditor at a date or dates in the future*" (SNA, 2008, pp. 446). However, it does not provide a straightforward definition of the government or public debt, but only refers to the other manuals, like GFSM or MGDD for details on the debt recording (SNA, 2008, pp. 448). In addition, neither ESA 95 nor ESA 2010 (EC, 2002, pp. 197; Eurostat 2014, pp. 384) conceptual frameworks give any specific definition of government or public debt. Instead, the MGDD points out that the government debt statistics can be compiled from provisional definition of general government sector and valuation rules of financial liabilities given in ESA. According to these provisions, government debt can be compiled as the stock of government liabilities at their market value in the closing balance sheet of the general government sector. In other words, the stock of the government liabilities equals the sum of all liabilities of general government sector, including currency and deposits, securities other than shares, financial derivatives, loans, other accounts payable, and in some cases technical insurance reserves and shares, all recorded at market value (where applicable).[2]

However, government debt statistic of the EU countries that is usually referred by the EU institutions and general public is compiled according to the government debt definition stemming from the provisions given in the Protocol on the Excessive Deficit Procedure

[2] The ESA 95 definition, pp. 197; the ESA 2010 definition slightly differs, e.g. special drawing rights are also regarded as a possible source of liabilities.

(henceforth the Protocol), annexed to the Treaty on European Union (colloquially known as Maastricht Treaty). While the Maastricht Treaty obliges EU member states to avoid excessive deficits and high public debts, the Protocol defines quantitative criteria for surveillance of excessive deficits and indebtedness, as well as government debt definition: "*debt means total gross debt at nominal value outstanding at the end of the year and consolidated between and within the sectors of general government*."[3] This definition has been supplemented by the EU Council regulation, which specifies components of government debt according to the ESA provisions on financial liabilities (No 3605/93, No 479/2009). According to the Protocol, debt is calculated as a sum of the three ESA liability categories - currency and deposits, debt securities[4] and loans - at the end of the given year. The government debt defined according to the Protocol and Council regulation is commonly referred to as the EDP debt or the Maastricht debt.

The Maastricht debt and government debt according to the general ESA provisions differs in two important aspects[5]: the Maastricht debt is recorded at nominal value (approximated by face value) and it excludes some ESA categories from financial liabilities, like derivatives and other accounts payable. Other important aspects of Maastricht debt definition are related to the notion of gross and consolidated debt. Gross debt means that debt is measured on gross basis, without netting with government asset positions. Consolidated debt means that liabilities of some government unit that is held by some other government unit are not counted when debt statistic is compiled. It should be also mentioned that debt is recorded in national currency; if liabilities are denominated in foreign currency, they are converted into the national currency at the spot market rate prevailing on the last working day of a given year (ESA, 2014, pp. 387)

While EU member states compile and report debt statistics using Maastricht definition, Serbia has national methodologies that define public debt. The current legislation stipulates two definitions of public debt, which in turn leads to the reporting of two values of public debt. The Law on Public Debt[6] defines public debt as a total of liabilities of the Government of Serbia (GoS) stemming from the:

- Loans contracted and debt securities issued by the Republic. In reporting practice, this portion of the debt is referred as "direct" debt of central government level;

[3] Treaty on the Functioning of the European Union, Protocol 12

[4] In the ESA 95, debt securities as ESA category also encompass derivatives, but derivatives were excluded from government debt definition given by the Protocol. The ESA 2010 separates debt securities and derivatives, by setting the derivatives to be particular category of ESA framework.

[5] EDP notification tables pp.3

[6] RS Official Gazette, 61/2005, 107/2009, 78/2011, 68/2015 and 95/2018

- Debt of local governments or legal entities which is guaranteed by the Republic. Guarantees to other entities can be approved only for debt issued to fund capital expenditure. In reporting practice, guarantees to legal entities are referred as “indirect” debt of the central government level.

On the other hand, the Law on Budget System[7] prescribes the definition of “general government debt” as a sum of direct and indirect debt of all government levels, including local governments and social security funds, on a consolidated basis. Thus, the difference in definition of the public debt imposed by these two laws comes from the different scope of the public sector units coverage. When compared to Maastricht definition, the definition stipulated by the Law on Budget system is closer in terms of units coverage, but there is a methodological difference in statistical treatment of guarantees. The issue of the guarantees treatment in debt statistics reporting is discussed in more detail in the subsection on contingent liabilities. Since recently, Serbian fiscal authorities have been also reporting the value of public debt according to Maastricht definition.

In this work, the general use of term public debt in the rest of the text refers to government debt according to the Maastricht definition for the EU member states. In the case of Serbia, public debt refers to public debt definition stipulated by the Law on Public Debt, if the different definition is not particularly emphasized.

2.1.4 Public debt structure

The public debt portfolio is usually the largest financial portfolio in the country, taking into account the size of the public sector and the comprehensiveness of the public debt conceptual definition. While the international organizations provide general guidelines on definition of public debt for the purpose of national accounting, the government authority in charge for the public liabilities, in literature colloquially referred to as Debt Management Office (DMO)[8], closely monitors and produces statistics and reports on features of public debt structure. The reporting on public debt structure in terms of scope, content and soundness is country-specific and primarily depends on organizational and institutional development of public financial management and administrative capacities of DMO staff. Nevertheless, several key features of the public debt structure are usually covered by DMO reporting regardless of its capacities, as shown in Figure 2.2. These features can be systematized as follows (Cosio-Pascal, 2009):

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[7] RS Official Gazette, 54/2009, 73/2010, 101/2010, 101/2011, 93/2012, 62/2013, 63/2013, 108/2013, 142/2014, 68/2015, 103/2015, 99/2016, 113/2017, 95/2018 and 31/2019

[8] Serbian DMO is established as an administration under the authority of the ministry in charge of finance under the name Public Debt Administration (PDA).

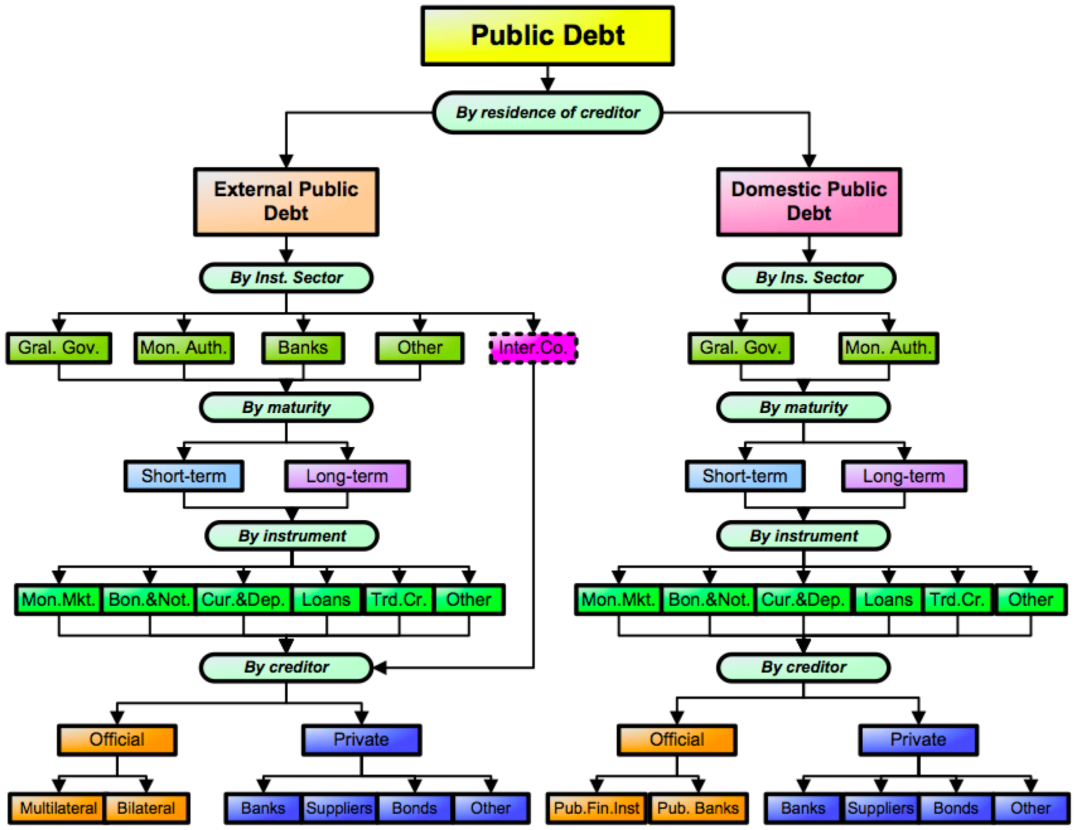


Figure 2.2: Key aspects of the public debt structure
Source: *Cosio-Pascal 2009, pp. 27*

1. Residence of a creditor. The legislation on public debt usually recognizes the notions of "external debt" and "domestic debt", according to the simple rule on residence of the creditor: regardless of the currency of the loan, if the creditor's residence is abroad, the loan is considered as external, and if the creditor is a national resident, the loan is considered as domestic. In the case of emerging economies where domestic financial markets are still underdeveloped and shallow, external financing of the public debt tends to exceed domestic financing. This is illustrated in Figure 2.3, which shows structure of the Serbian public debt by residence of creditor.

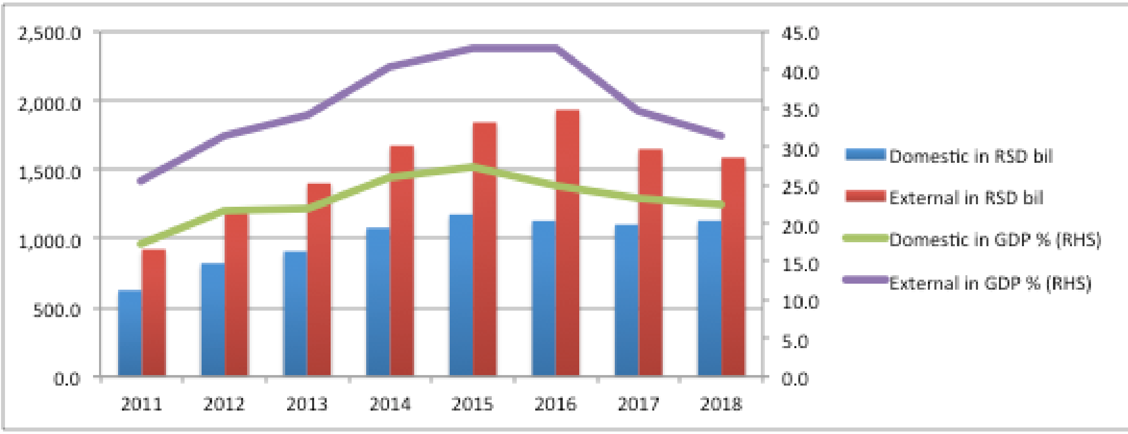


Figure 2.3: Structure of the Serbian public debt by the residence of creditor

Source: *PDA data and own calculation*

2. The currency of denomination. Domestic debt denominated in domestic currency, and external debt denominated in respective foreign currency of the creditor' country is an expected outcome of external borrowing, so that currency structure of the public debt corresponds to structure by the residence of creditors. In reality, developed countries with strong and stable currencies, like USA, Denmark or EMU, have both external and domestic debt denominated in domestic currency. On the other side, emerging economies with volatile exchange rates often face difficulties or impossibilities to borrow in nominal terms in the domestic currency, even at domestic markets. This phenomenon is well-known as original sin (Eichengreen et al., 2002). Thus, currency of denomination is an exceptionally important aspect of public debt structure in emerging economies like newer EU member states, as illustrated in Figure 2.4.

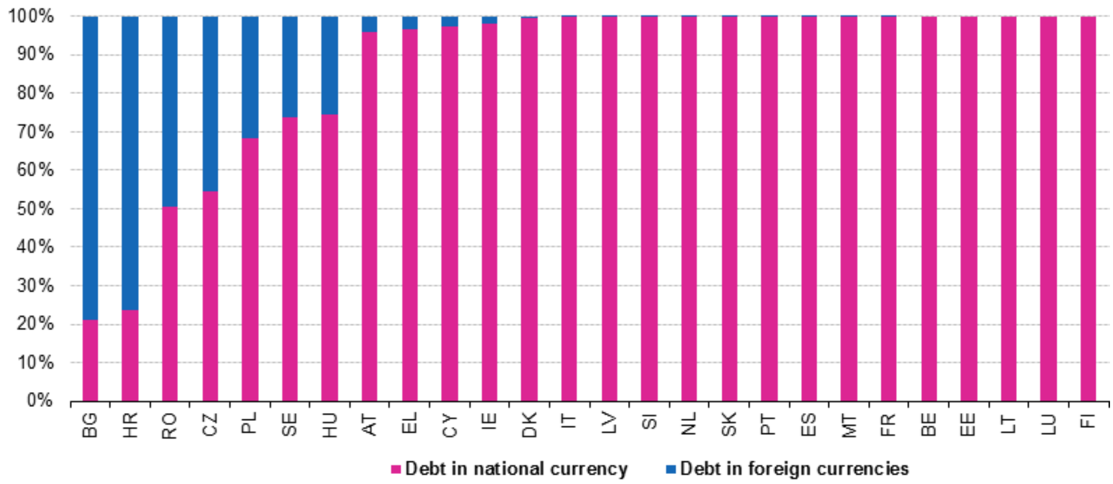


Figure 2.4: Public debt of EU countries in 2017, breakdown by currency

Source: *Eurostat*

3. Institutional sector. Following the definition of the public sector, all liabilities of the general government units, monetary authorities and public corporations are considered as public debt. Yet, the legislation on public debt may stipulate institutional arrangements of the private-public partnership, where borrowing of the private entities is considered as part of the public liabilities. Such arrangements are characteristic for the external borrowing and include loans with public guarantee for private banks and corporations, or inter-company lending for private corporations that have joint ventures with public corporations (Cosio-Pascal, 2009).

Central government debt is the most dominant component of the pubic indebtedness, as illustrated in Figure 2.5. The share of other general government subsectors may significantly vary across countries, depending on the administrative organization of the government and level of fiscal decentralization.

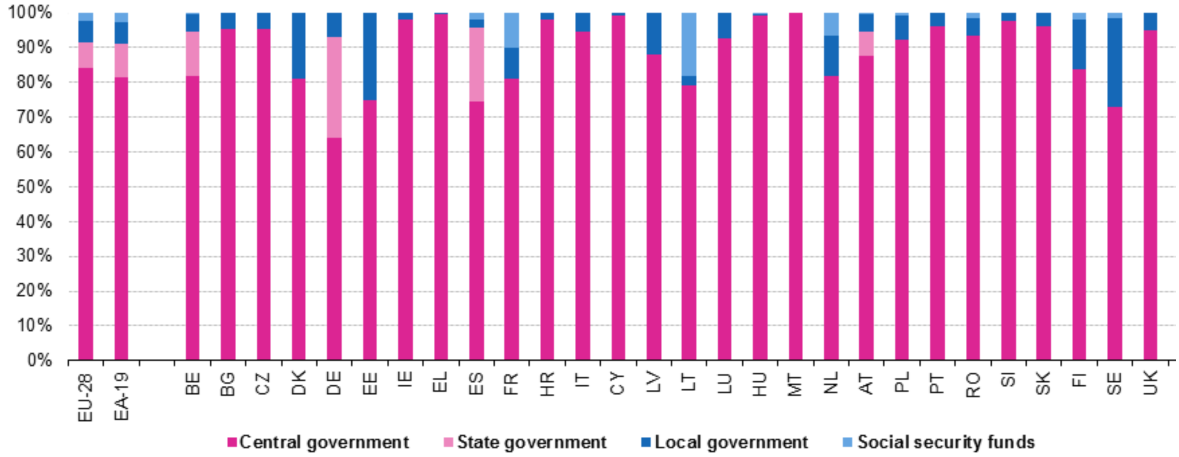


Figure 2.5: Public debt of EU countries in 2017, breakdown by general government subsectors

Source: *Eurostat*

4. Maturity. The generic approach to maturity in financial analysis classifies all financial instruments into short-term (maturity up to one year) and long-term (maturity above one year). In the context of debt management, there are two notions of the maturity concept: original maturity, which refers to total life length of the debt instrument, and residual (remaining) maturity, which refers to the time length remaining for the debt to be fully repaid. The informational content of the residual maturity statistics is particularly important in the risk analysis of public debt portfolio since amount of debt falling due in short period is exposed to same risks as short-term debt. Short-time financing is less preferred being perceived as more risky type of funding due to uncertainty about future development of the market conditions, despite its lower interest rates stemming from the higher market liquidity and lower maturity risk premiums. Thus, long-term debt instruments dominate in the term structure of the government debt portfolio (Figure 2.6).

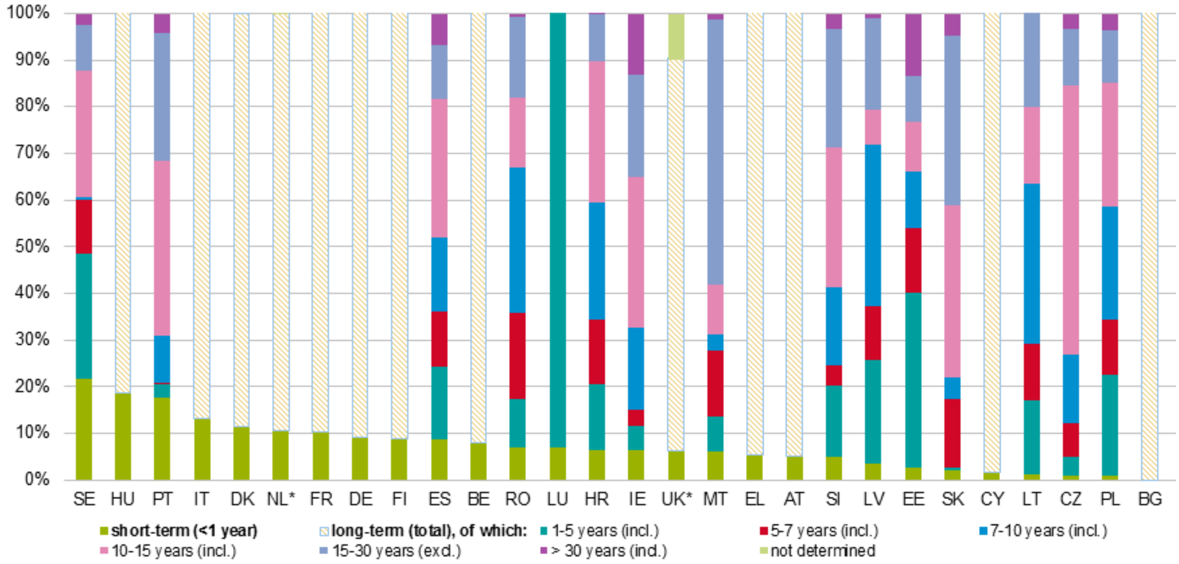


Figure 2.6: Public debt of EU countries in 2017, breakdown by initial maturity

Source: *Eurostat*

5. Type of instrument. According to the provisions Council Regulations, No 479/2009, government debt (Maastricht definition) comprises only the following instruments:

- Currency and deposits: currency in circulation and all types of deposits in national and in foreign currency;
- Debt securities: negotiable financial instruments usually traded on secondary markets or can be offset on the market, and do not grant the holder any ownership rights in the institutional unit issuing them.
- Loans: financial instruments created through direct arrangements between creditor and debtor, either directly or through brokers, which are either evidenced by non-negotiable documents or not evidenced by documents.

Typical forms of debt securities are treasury bills and bonds. Treasury bills are short-term securities considered as the money market debt instruments traded at some discount rate at organized markets. Treasury bonds are the generic term applied to all government long-term securities, however in the strict sense, long-term security is considered as a treasury note if its maturity is between 1 to 5 years, or bond if its maturity is over 5 years. Government loans may be contracted at prevailing conditions on financial markets. Yet, in case of emerging and developing economies international creditors are often willing to provide loan funding at fixed interest rates lower than market rates; such loans are called concessional loans. In advanced countries, most dominant form of debt financing is issuance of debt securities, while particular ratio between securities and loans in the government debt countries may vary across countries, as shown in Figure 2.7. The share of currency and deposits in the government debt structure is normally low or neglectable.

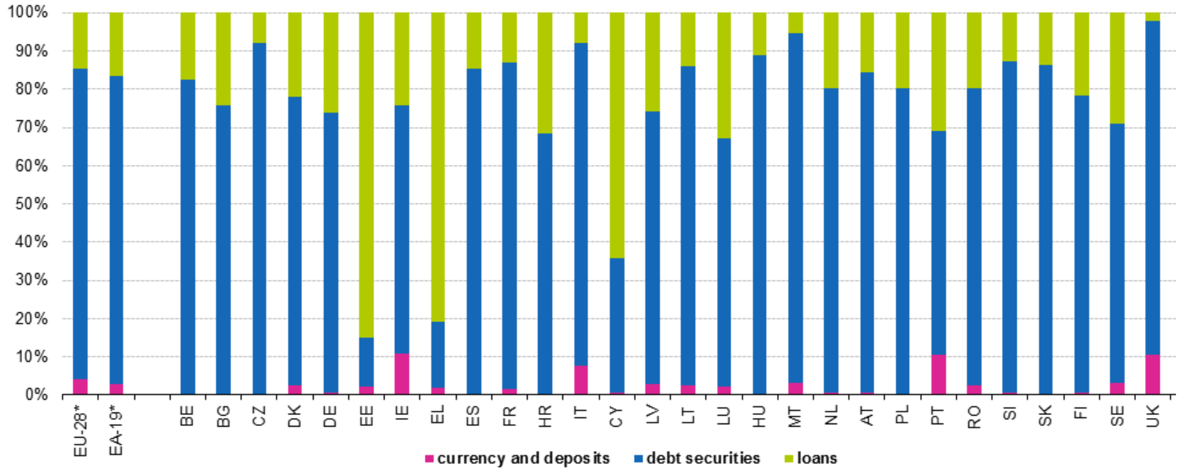


Figure 2.7: Public debt of EU countries in 2017, breakdown by instrument
Source: *Eurostat*

Apart from the Maastricht definition of government debt, a broader view according to SNA considers some other liabilities of the public sector units as an integral part of the public debt, most importantly trade credits and arrears. Trade credits consist of claims or liabilities arising from the direct extension of credit by suppliers for transactions in goods and services, and advance payments by buyers for goods and services and for work in progress, while arrears are defined as liabilities which due date has expired (Cosio-Pascal, 2009).

6. Interest rates. Interest rate structure of public debt is closely connected concept to term structure of public debt portfolio, due to the similarities in the risk exposures to unanticipated changes in market interest rates; while short-term debt has to be refinanced at new interest rate, debt issued at variable interest rate has to be re-fixed at new interest rate. Accordingly, borrowing at variable rates is conceived as riskier for DMO managers, who tend to issue debt at fixed rates, while lenders tend to offer funding at variable interest rates. A public borrowing at variable interest rates is more frequently incurred in case of loans since debt securities are usually issued at fixed coupon rates. Consequently, the interest rate structure appears as an important indicator of public debt portfolio structure for the emerging and developing countries which are often forced to finance deficits by contracting loans. These points are illustrated in Figure 2.8, which provides interest rate structure of Serbian public debt separated to the central and local government levels. The lenders perceive central government as less risky than local level, thus share of debt at variable interest rates in local government units is considerably higher when compared to central level.

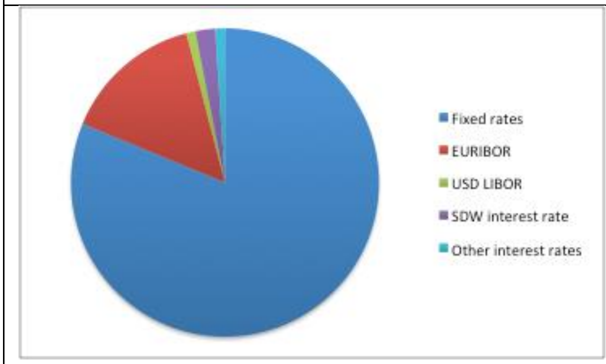
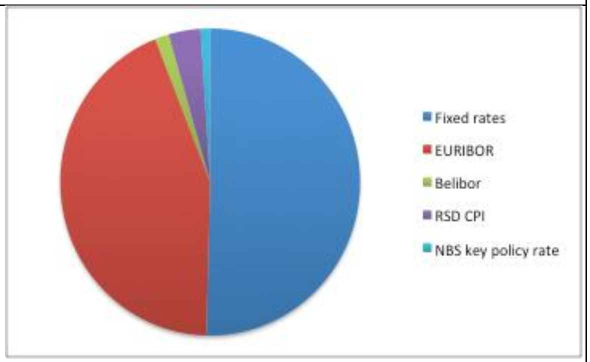
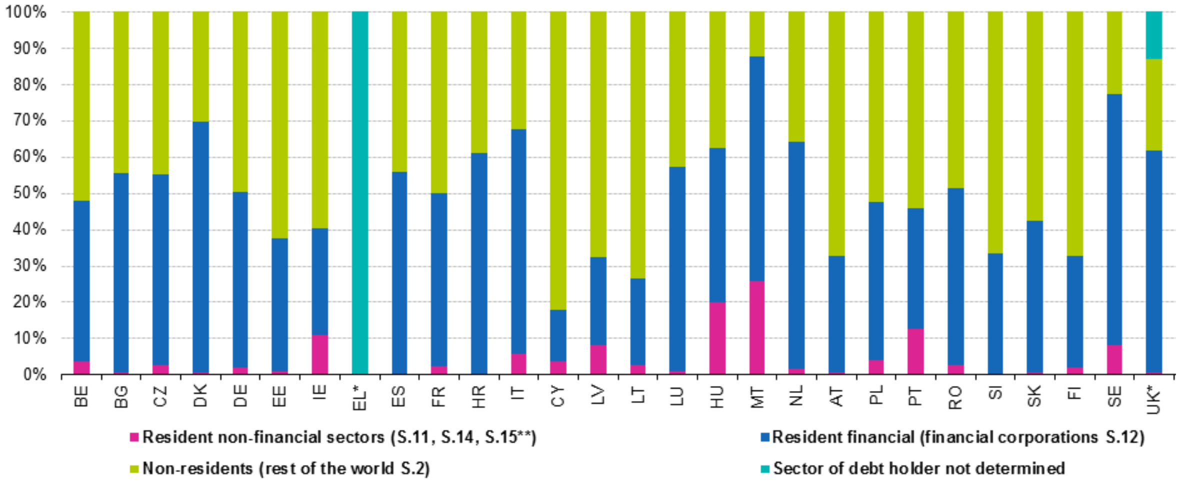
Central government debt	**Local government debt**
	

Figure 2.8: Structure of the Serbian public debt by interest rates
Source: *PDA data and own calculation*

7. Type of creditor

Creditors of the public debt can be grouped according to several criteria, like residence of creditor (external and domestic, which was already discussed) or institutional sector (non-financial and financial). An illustration of the debt structure according to these two criteria for EU countries is shown in Figure 2.9. While share of foreign-credited debt varies extensively among EU countries, domestic debt is mostly owned by the units from financial sector, as expected.



2.9: Public debt of EU countries in 2017, breakdown by debt holder
Source: *Eurostat*

Another useful consideration of debt creditors grouping is quality (Cosio-Pascal, 2009). According to this criterion, creditors can be regarded as either official – those whose resources for lending are coming from their public budgets, or private – those using private sources for lending. Official creditors can be further grouped to bilateral and multilateral. In the case a bilateral creditor the funding source is the budget of a single government, while in the case of a multilateral creditor, the funding source is various governments' contributions to a money lending multilateral agency, such as the World Bank and the IMF. On the other hand, ownership of debt by private creditors depends on the type of debt instrument: while government debt securities are bought by all residential sectors (financial corporations, non-financial corporations and households), domestic debt in form of loans is usually owned by the private banks.

2.1.5 Contingent liabilities

Contingent liabilities are conceived as obligations that do not arise unless a particular, discrete event occurs in the future. The issue of contingent liabilities is regarded as an important subject in the analysis of the fiscal sustainability of emerging and developing economies. For instance, Anderson (2004) study of public debt dynamics shows that the activation of the contingent liabilities contributes nearly 50% to the increase in public debt in a sample of 21 emerging markets.

It is clear that contingent liabilities fit neither SNA definition of government liabilities nor Maastricht definition of government debt. Nevertheless, lessons learned from historical experience imply that contingent liabilities can suddenly turn to public debt during the economic downturns, such as the recent global crisis. Hence, treatment of the contingent liabilities remains one of the most debated issues in defining scope of public debt portfolio. As reads in GFSM (2014), explicit contingent liabilities are defined as legal or contractual financial arrangements that obliged government to acquire some liability if particular event occurs. Implicit contingent liabilities do not arise from a legal or contractual source but are recognized after a triggering condition or event is realized. More specifically, explicit contingent liabilities can be roughly grouped into:

- One-off guarantees to liabilities of other entities, such as publicly guaranteed debt of public corporations;
- Contingent liabilities that are not in the form of guarantees. Typical examples are legal claims stemming from the pending court cases, or indemnities against unforeseen tax liabilities arising in government contracts with other units.

On the other hand, implicit contingent liabilities are related to the events wherein public expects that the government will acquire liabilities without having legal obligation to do so, for the sake of public interest. A typical example, very actual due to the accelerated population aging, is net implicit obligation for future retirement benefits, i.e. total of earned citizen’s pensions less total pension contribution. Other cases of implicit contingent liabilities comprehend expenditures for recovery from natural disasters, coverage of outstanding debt of local government units in case of default or stabilization of banking sector in case of banking crisis.

Opposite to explicit contingent liabilities, probability of implicit contingent liabilities activation and amount of obligation which will occur is not easy to anticipate. Consequently, implicit contingent liabilities are mostly subject to fiscal vulnerability analysis, whereas fiscal statistics report information about explicit contingent liabilities. As previously discussed, Maastricht definition of public debt does not comprehend contingent liabilities as government debt. By contrast, both public debt definitions stipulated by the Serbian legislation (Law on Public Debt, Law on Budget System) conceive one-off guarantees as a part of public debt. Serbian public debt accounted in accordance with both national methodologies and Maastricht's definition is presented in Table 2.1.

Table 2.1: Serbian public debt, national and Maastricht definitions, end of 2018

Debt definition	**Law on Public Debt**		**Maastricht**		**Law on Budget System**	
Liability type	RSD mil	% of GDP	RSD mil	% of GDP	RSD mil	% of GDP
Direct liabilities of the central government level	2,540,066	50.2	2,464,310	48.7	2,540,066	50.2
Indirect liabilities of the central government level	153,838	3.0	96,658	1.9	153,838	3.0
Other liabilities of central government	0	0.0	318	0.0	318	0.0
Debt of local governments	26,298	0.5	63,074	1.2	63,074	1.2
Debt of social security funds	0	0.0	0	0.0	0	0.0
Public debt total	2,720,202	53.8	2,624,361	51.9	2,757,295	54.5

Source: *PDA data*

As reads from the table, Maastricht definition yields the lowest level of public debt, due to a large amount of guarantees (3% of GDP) which does not fall under the scope of Maastricht definition. Fiscal Council (2012) analyzed pros and cons of the national and international methodologies looking for a definition that will produce the most realistic assessment of Serbian public debt. The analysis concludes that appropriate solution should in a way reflects the probabilities of contingent liabilities (as well as arrears) activation. For instance, Council proposes the hybrid methodology that comprehends direct public debt and guarantees weighted by the probabilities of activation, whereby probabilities would be estimated from the financial conditions of the entities which debt is guaranteed. Yet, as of 2019 PDA public debt reporting remains attached to national methodologies.

2.2 Debt accumulation equation

The debt accumulation equation (DAE) is a workhorse of debt and fiscal sustainability analysis. It addresses changes in public debt over time to fundamental determinants of its dynamics and serves as a tool for the debt projections and subsequent debt sustainability analysis. In order to provide a detailed explanation of debt accumulation dynamics, this section builds up analytical framework that gradually shifts from the theoretical level of the debt accumulation mechanics toward practical issues of the debt servicing costs and fiscal balance measurements, all supported by the appropriate illustrations.

2.2.1 Mechanics of the debt accumulation

As been previously discussed, public debt on the aggregate level is a sum of government liabilities that require payment of interest and principal. If the government liability i, outstanding at time t, is denoted as $L_{i,t}$, and government portfolio consists of N liabilities, then the aggregate public debt D_t reads as

$$D_t = \sum_{i=1}^{N} L_{i,t}. \tag{2.1}$$

On the technical level, aggregate change of public debt at time t is simply equal to a differential of public debt dynamics,

$$\Delta D_t = D_t - D_{t-1}. \tag{2.2}$$

The essential theoretical question is what determines the level of public debt change. Since the liabilities outstanding at time $t-1$ require payments of interest and/or principal falling due at time t, this will be for sure one of the debt change determinants. Besides, government operations require spending of financial resources, which are covered from the public revenue, such as taxes and social contributions. The net result of government operations will also influence the borrowing needs of government since any shortage of financial resources to fund operations has to be settled through issuance of new debt. Hence, expected change of public debt D_t^*, in the most general sense, can be conceptually decomposed to two main components: debt servicing costs DSC_t and result of government operations RGO_t (other than debt servicing operations):

$$\Delta D_t^* = DSC_t + RGO_t. \tag{2.3}$$

Debt servicing costs are generic term encompassing all (accrued or cash) financial outflows[9] stemming from the government liabilities from the previous period, $DSC_t = f(D_{t-1})$. For the sake of simplicity, it is assumed that:

- all liabilities are either loans or securities (contingent liabilities or arrears are not considered as a public debt according to Maastricht definition, while the share of deposits and currencies in public debt is minimal, as illustrated in Figure 2.7 and thus neglected);
- debt servicing costs of the public debt portfolio at time t consists only of interest payments and principal payments falling due at time t (seldom debt servicing costs

[9] Accounting of public sector can be based on accrual or cash principle.

with minor impact on debt accumulation, like provisions and penalties, are neglected).

Under this generalization, the composition of the debt servicing costs reads as

$$DSC_t = INT_t + F_t^M, \tag{2.4}$$

where INT_t and F_t^M are an aggregate amount of interest payments and amount of loans or security principals maturing at time t.

On the other side, the result of government operations is public finance accounting category derived from the government financial statements. Accounting conventions propose several indicators of government operations' result that differ in scope of operations coverage. It is important to underscore that interest and principal payments are also form of government operations, but their categorization in public finance accounting practice is different: interest payments are regarded as current expenditures, while principal payments are regarded as financial transactions. Two most important macroeconomic indicators of the government operations' result exactly differ in coverage of debt servicing costs:

1. Primary fiscal (government) balance $\boldsymbol{PB_t}$ – covers the result of all government operations except interest payments.

2. Overall fiscal (government) balance $\boldsymbol{OB_t}$ – covers all government operations, including payment of both interest and principal. Since the interest payments are negative financial outflow, overall fiscal balance equals primary balance less interest payments,

$$OB_t = PB_t - INT_t \tag{2.5}$$

The rationale to separate interest payments from other government operations in the context of fiscal sustainability analysis is coming from the fact that the structure of government balance may raise additional concerns about the solvency of public debt. Even if government runs stable level of primary deficit to GDP, overall deficit can increase over time due to an increase in interest payments. As overall balance covers result of all government operations, the most general form of debt accumulation equation can be written as a macroeconomic identity given as follows:

$$D_t^* = D_{t-1} - OB_t, \tag{2.6}$$

where D_t^* and D_t denote equation and actual values of government debt, respectively, while OB_t denotes overall government balance at time t. Alternatively, if primary balance is used as a measure of result of government operations, the previous equation reads as:

$$D_t^* = D_{t-1} - PB_t + INT_t, \tag{2.7}$$

Further, if the currency structure of debt portfolio is neglected and interest payment is simply calculated by applying uniform nominal interest rate i to stock of outstanding debt from the previous year, $INT_t = i_t D_{t-1}$, debt accumulation equation can be rewritten as:

$$D_t^* = (1 + i_t)D_{t-1} - PB_t. \tag{2.8}$$

This equation tells that two basic determinants of debt-creating flows are the interest rate and primary balance. Their riskiness is substantially different, as the interest rate is a variable determined by the financial markets' forces and decisions of the monetary authorities, while primary balance is determined by the means of fiscal policy and governmental decisions. However, assumption on uniform debt structure and uniform interest rate may be over-simplistic, especially in case of emerging economies, which most likely borrow money from foreign markets or international creditors. The presence of debt instruments denominated in foreign currency, which debt servicing costs are counted at foreign interest rate, brings additional market risk issues in managing government debt portfolio. Thus, debt accumulation equation can be further modified to explicitly encompass effects of foreign interest rate and foreign exchange rate on debt-creating flows,

$$D_t^* = (1 + \Delta fx_t)\left(1 + i_t^f\right)D_{t-1}^f + \left(1 + i_t^d\right)D_{t-1}^d - PB_t, \tag{2.9}$$

where Δfx_t is a depreciation of the foreign currency[10], i_t^f and i_t^d are foreign and domestic interest rates, D_{t-1}^f is nominal value of debt denominated in foreign currency, and D_{t-1}^d is nominal value of debt in domestic currency.

The form of debt accumulation equation as given in (2.9) describes the basic mechanics of debt dynamics on the aggregate fiscal and macroeconomic levels. Also, it represents the first step in methodological procedure of the debt dynamics decomposition to fiscal and non-fiscal determinants, which is discussed later on. Nevertheless, empirical analysis requires practical measurement of the theoretical concepts such as overall and primary balance, as well as measurement of the debt servicing costs, to provide adequate fiscal sustainability assessment. The following subsections deal with measurement issues of debt

[10] Exchange rate is measured as a relative price of local currency per unit of foreign currency

servicing costs and result of the government operations in financial and accounting practice.

2.2.2 Arithmetic of debt servicing costs

Since public debt portfolio consists of a large number of debt instruments, debt servicing costs on aggregate level equals the sum of respective debt servicing costs of each instrument $DSC_{i,t}$:

$$DSC_t = \sum_{N}^{i=1} DSC_{i,t}, \tag{2.10}$$

where N denotes the number of instruments in the portfolio. On a particular level, computation of the debt servicing costs may be complex tasks in case of the so-called "exotic" debt instruments, such as loans that include grace periods, tranches, provisions, penalties for non-execution, specific amortization formulae, etc. Yet, plain vanilla debt instruments can be roughly divided into two categories:

- Bullet debt instruments, where the entire principal falls due at the end of the instrument lifetime, while interest is paid periodically on a regular basis. Such system of debt reimbursement is characteristic of notes and bonds.
- Amortizing debt instruments, where certain amounts of principal are reimbursed over the lifetime of debt instrument, usually at the same time when interest is paid down. Such a system of reimbursement is characteristic of the loans.

In case of bullet debt instrument j (usually coupon bond), the interest payment is simply computed using the following formula:

$$INT_{j,t} = F_{j,0}\left(i_{j,t}/k_j\right), \tag{2.11}$$

where $F_{j,0}$ is contracted debt principal of j th instrument, k_j is the frequency of compounding within a year, $INT_{j,t}$ is interest payment at time t, and $i_{j,t}$ is respective annual coupon rate, which can be either fixed (commonly) or variable if it is indexed to some variable interest rate. Principal $F_{j,0}$ is fully repaid at the end of bond lifetime.

Amortizing loan j is usually reimbursed in the form of equal annuities, which are composed of both interest and principal payments:

$$AN_{j,t} = INT_{j,t} + F_{j,t}^{M}, \tag{2.12}$$

where $AN_{j,t}$ is annuity amount falling due at time *t*, decomposed to respective amounts of interest payment $INT_{j,t}$ and principal payment $F_{j,t}^{M}$. An annuity can be directly computed applying the formula:

$$AN_{j,t} = F_{j,0} / \left[\frac{1-\left(1+i_{j,t}/k_j\right)^{-T_j k_j}}{i_{j,t}} \right], \tag{2.13}$$

where T_j is the maturity of loan in years. Since principal is gradually amortized, interest rate at given time *t* is applied to the outstanding (unpaid) amount of principal F_j^O at time *t*-1, $INT_t = F_{j,t-1}^{O}\left(i_{j,t}/k_j\right)$. The outstanding amount of principal at time *t*-1 is simply computed as difference between full amount of principal and sum of reimbursed principal payments, $F_{j,t-1}^{O} = F_{j,0} - \sum_{k=1}^{t-1} F_{j,k}^{M}$.

An illustration of the *DSC* computation is provided based on the simple mock portfolio that consists of four representative debt instruments: one T-bill, one T-bond with fixed coupon payments, two amortizing loans reimbursed at equal annuity schedule. The supposed characteristics of the portfolio debt instruments are given in Table 2.2.

Table 2.2: Representative portfolio of debt instruments

Debt portfolio	**A**	**B**	**C**	**D**
Type of debt	**T-bill**	**T-bond**	**Fixed interest loan**	**Floating interest loan**
Settlement date	1/1/17	1/1/17	1/1/17	1/1/17
Maturity date	1/7/17	1/1/20	1/1/21	1/1/21
Face value (original currency)	200,000	500,000	2,560	3,250
Currency	RSD	RSD	USD	EUR
Exchange rate	N/A	N/A	117.19	123.08
Face value (RSD)	200,000	500,000	300,000	400,000
Reference interest rate	discount rate, 2.5%	coupon rate, 3.0%	fixed rate, 2%	1Y LIBOR + 3.5% = 5.2%
Payment frequency	2	2	2	1
Inflation-linked				
Market price (for securities)	197,531	457,330	N/A	N/A
Yield to maturity (for securities)	2.5%	3.5%	N/A	N/A

Source: *own calculation*

As reads from the table, all debt instruments are issued at 01/01/2017. The 6-month T-bill A and 3-year T-bond B are issued in RSD and sold at discount rates 2.5% and 3.5%, respectively. Concessional loan C in USD is contracted at 2% fixed interest rate, which is lower than the comparable discount rate of T-bond. Finally, loan D is contracted at floating rate, so its reference interest rate is composed of 1-year LIBOR plus 3.5% spread. Using the formulae for interest payments of bullet debt and annuity payment of amortizing debt, debt servicing costs of this mock portfolio can be easily computed. The schedule of debt servicing costs in RSD over the 4-year lifetime of total portfolio at 6-month time intervals is presented in Table 2.3.

Table 2.3: Debt servicing costs of the representative portfolio of debt instruments

Debt portfolio	**A**	**B**	**C**	**D**	**Debt servicing costs**
1/7/17	200,000	7,500	40,953		248,453
1/1/18		7,500	40,953	113,356	361,808
1/7/18		7,500	40,953		248,453
1/1/19		7,500	40,953	113,356	361,808
1/7/19		7,500	40,953		48,453
1/1/20		507,500	40,953	113,356	661,808
1/7/20			40,953		40,953
1/1/21			40,953	113,356	154,308

Source: *own calculation*

Eventually, debt servicing costs of the total debt portfolio at a given period are computed simply as a sum of debt servicing costs of particular instruments.

2.2.3 Traditional framework of the government operations accounting

As previously discussed, the first edition of the IMF's GFSM published in 1986 was the first comprehensive manual based on SNA principles, aiming to align national methodologies in public finance accounting. Until 2001, when second edition of the manual with significant methodological changes was published, majority of the countries compiled government finance statistics in compliance with GFSM 86 guidelines, using accounting principles of recording transactions on a cash basis. Since the introduction of the second edition of the GFSM in 2001 until present days, developed economies mostly adopted new practices of recording government transactions on accrual basis using new analytical framework of public finance accounting. On the other side, many emerging and developing countries, like Serbia, remain attached to the "traditional" cash-based accounting while struggling to introduce advanced accounting practices proposed by the newer versions of the GFSM. The traditional framework of recording government operations, according to the GFSM 1986 is presented in Table 2.4.

Table 2.4: Government operations according to the GFSM 1986

Revenue and grants	**Expenditure and net lending**
Revenue	Current expenditures
Revenue from taxes (including social security contributions)	Goods and services
Non-tax revenue	Salaries and other compensations of employees
Capital revenue (including disposal of fixed assets)	Social security payments
Grants	Other goods and services
	Interest payments
	Subsidies
	Transfers
	Capital expenditures and transfers
	Net lending
Deficit (-) / Surplus(+) on a cash basis	
Financing (domestic or foreign)	

Source: *https://www.minfin.bg/upload/1450/GFSM-2001-meta-EN.pdf*

The main result of the government operations defined by the GFSM 1986 is government deficit or surplus on a cash basis. The government deficit/surplus is regarded as a traditional measure of the overall fiscal balance OB_t.

As of 2018, Serbian fiscal authorities apply the nationally developed concepts and definitions of GFS based on the GFSM 1986 (IMF, 2018). The national methodology is stipulated in the Law on Budget System. The main features of the national methodology are:

- the institutional coverage of the data corresponds to the consolidated general government.
- Republican budget includes revenues (including grants) and expenditures (including activated guarantees, except those of PE Roads of Serbia) – all of which are included in overall fiscal balance.
- financing includes all proceeds (including privatization proceeds) and expenses associated with transactions in financial assets and liabilities.
- revenue covers tax revenue (according to the nature and base of the tax), non-tax revenue (including capital revenue) and grants;
- expenditures covers current expenditures, capital expenditures, budget lending and activated guarantees.

- financing outflows covers foreign and domestic debt repayment and acquisition of financial assets
- financing inflows covers foreign and domestic borrowing, privatization receipts and receipts from repayment of loans.

An example of the public finance statistics for 2018 that is reported by the Serbian ministry in charge of finance is given in Table 2.5. Public finance statistics are compiled according to the described national methodology. In 2018, consolidated government deficit as a measure of overall balance was in surplus 0.6% of GDP, while primary balance was around 2.7% of GDP (overall balance + 2.1% of GDP interest expenditures).

Table 2.5: Government financial statistics of the Republic of Serbia (in % of GDP) according to national methodology, year 2018

Revenue and proceeds		**Expenditure and outflows**	
Public revenue (including grants)	41.6	Public expenditure	41.0
Current revenue	41.3	Current expenditure	36.5
Tax revenues	36.0	Compensation of employees	9.3
Personal income tax	3.5	Goods and services	6.8
Corporate income tx	2.2	Interest payments	2.1
Value added tax	9.9	Subsidies	2.2
Excises and customs	6.6	Transfers	14.7
Other tax revenue	1.5	Other current expenditure	1.4
Social contributions	12.2	Capital expenditure	3.9
Non-tax revenue	5.3	Activated guarantees	0.4
Donations	0.3	Budget lending	0.1
Consolidated government deficit/surplus		**0.6**	
Proceeds	8.7	Outflows	9.4
Privatization proceeds	0.1	Principal payment to domestic creditors	5.2
Proceeds from debt repayment	0.4	Principal payment to international creditors	4.0
Domestic lending	5.9	Acquisition of financial assets	0.2
International lending	2.3		

Source: *Ministry of Finance, SRB*

2.2.4 Recent developments in government operations accounting

In 2001, the IMF published second edition of the GFSM, wherein essentially different analytical approach to public finance accounting was introduced. Apart from switching from cash to accrual accounting, GFSM (2001) has introduced holistic approach to public finance reporting: similar to any other business entity in the private sector, government (or public sector in general) has its own assets, liabilities and operations that are recorded in relevant financial statements. Therefore, statistics of the government operations in the context of comprehensive asset-liability management have to be aligned with reporting on government assets and liability positions. The third edition of GFSM published in 2014 brought about some advances in the more precise and reliable recording of statistics, but framework and principles established by GFSM (2001) have not changed.

According to the GFSM (2014), the government should stipulate analytical framework based on a set of the following financial statements:

1. Balance sheet, which records the stock positions of government assets and liabilities, and respective net worth. The government assets position consists of non-financial[11] and financial assets, while liabilities are always considered as a financial position in balance sheet. Consequently, net worth of the government equals is accounted as a sum of net investments in non-financial assets and net financial worth, whereby net financial worth is obtained by netting financial assets with liabilities.

2. Statement of operations, which records all government transactions with other domestic or international entities. Government transactions are grouped into three categories: transactions affecting net worth (e.g. tax collection, compensation of employees), transactions in non-financial assets (e.g. investment in infrastructure building) or transaction in financial assets (e.g. sale of the equity of state-owned enterprises).

3. Statement of other economic flows, which records changes in stock positions of assets and liabilities that come for reasons other than transactions. The majority of those changes are stemming from the revaluation of stock positions due to the price and exchange rate movements, or discovery of new assets (like the discovery of new natural resources).

4. Statement of sources and uses of cash, which records cash inflows and outflows related to statement of operations. Such kind of financial statement is related to those countries which apply more advanced public sector accounting based on accrual accounting principles[12].

The full structure of the analytical framework that corresponds to the financial statements proposed by GFSM is presented in Figure 2.10.

[11] Non-financial assets in government balance sheet include fixed assets (building and machineries), inventories, valuables and non-produced assets (land and natural resources).
[12] Serbia is still practicing cash-based public sector accounting, yet, introduction of the accrual accounting in public sector is long-term strategic objective of the public financial management reform programme.

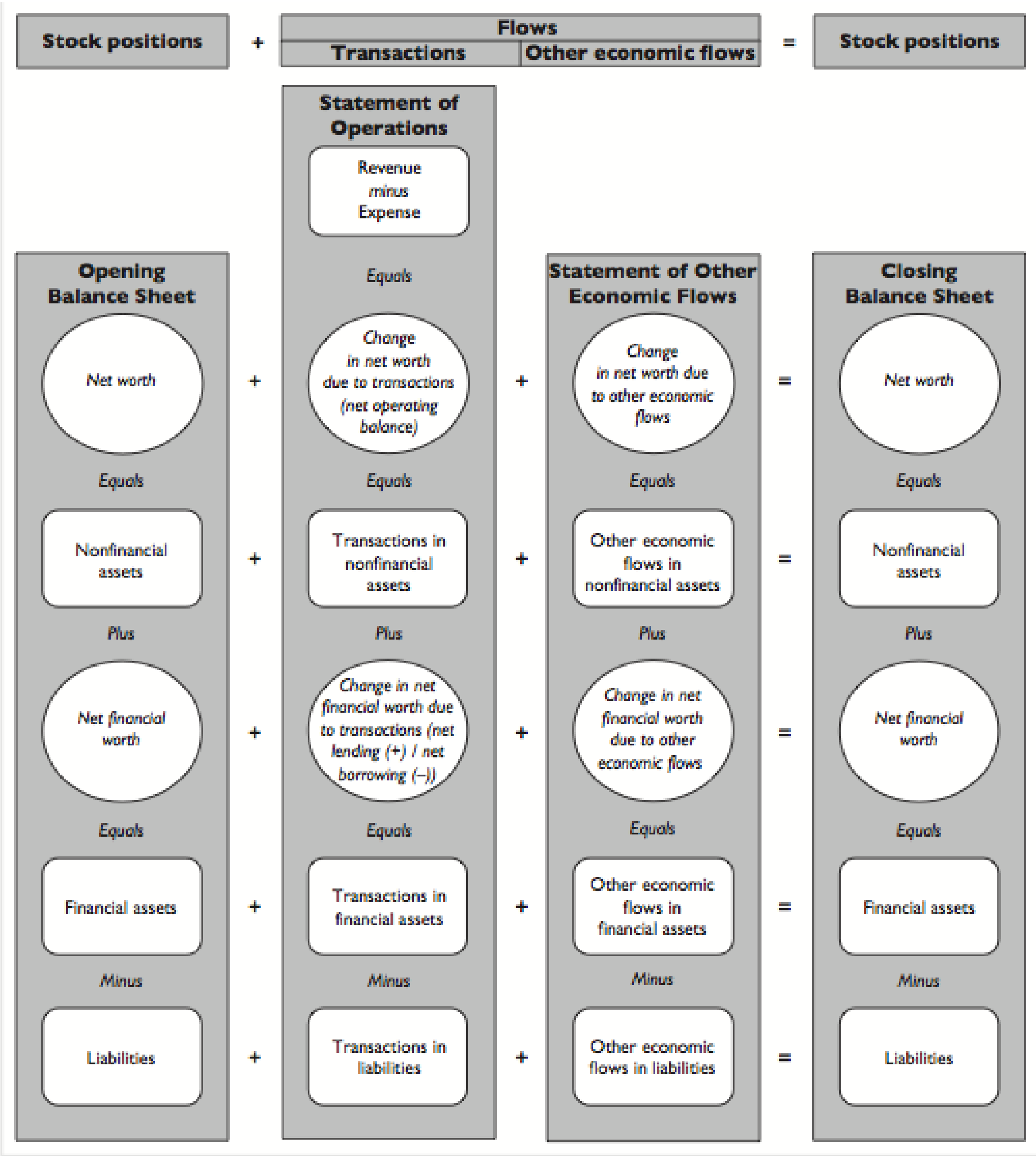


Figure 2.10: Public finance analytical framework
Source: *GFSM(2014), pp. 68*

By the presented scheme of public finance accounting, several important analytical balances that summarizes result of the government operations can be derived:

1. Gross operating balance. It equals the difference between government revenue and expense other than the consumption of fixed capital. The GFSM manual makes a difference between *government expense*, which includes only current transactions (such as compensation of employees) and capital transfers, and *government expenditure* that counts both government expense and net investment in non-financial assets. Consumption of fixed assets is a concept close to depreciation in corporate finance – it reflects the decline in the current value of the stock of fixed assets owned and used by a government unit as a result of physical deterioration, normal obsolescence, or accidental damage (SNA, 2008).

2. Net operating balance. Depending on the analytical purpose, the net operating balance can be computed and interpreted in two ways (as presented in Figure 2.10):

- as a difference between government revenue and expense, including consumption of fixed assets, indicating a summary measure of the sustainability of the government operations;
- as a sum of net investments in non-financial assets and net financial worth, reflecting a change of net worth (of the initial balance) due to government transactions.

Since many governments in emerging and developing countries do not compile statistics on the consumption of fixed assets, they usually report only net operating balance.

3. Net lending/borrowing position. Depending on the analytical purpose, Net lending/borrowing position can be computed and interpreted in two ways (as presented in Figure 2.10):

- as a difference between government revenue and expenditure (expense plus net investment in non-financial asset), reflecting a change in a net financial position due to the government transactions;
- as a difference between net acquisition in financial assets and net incurrence of liabilities, showing to which extent government is either financing other domestic sectors in the domestic economy or abroad, or spend the financial resources generated by other sectors in the domestic economy or from abroad.

These three indicators of the government operations' results are the public finance accounting categories, which are regularly reported by the countries that follow GFSM 2001 or GFSM 2014 methodology, like EU countries. This is illustrated in Table 2.4 which presents the statement of general government operations[13] of the Republic of Croatia being the newest EU member.

[13] While Croatian fiscal authority applies GFSM 2001, it still compiles data on cash basis principle

Table 2.6: Government financial statistics of the Republic of Croatia (in 000 HRK) according to GFSM 2001 methodology

No.	Description	2016	2017	2018
Transactions affecting net worth				
1	Revenue	150,088,571	158,056,575	161,906,779
2	Expense	150,558,643	152,714,569	155,436,095
	Net-gross operating balance (1-2)	-470,072	5,342,006	6,470,684
	Change in net worth: transactions (31+32-33)	7,849,473	8,085,706	7,215,850
Transactions in non-financial assets				
31	Net acquisition of non-financial assets			
	Net lending/borrowing (1-2-31)	-8,319,545	-2,743,700	-745,166
	Transactions in financial assets and liabilities (33-32)	8,319,545	2,743,700	4,866,951
32	Net acquisition of financial assets	-3,138,858	-2,850,381	9,918,410
33	Net incurrence of liabilities	5,180,687	-106,681	10,663,576

Source: *Ministry of Finance, HRV (2018)*

The net lending/borrowing as a result of government operations is obviously the closest to the concept of government deficit/surplus, as defined in GFSM (1986). For example, the ECB official statistics recognize the net lending/borrowing as measure of government deficit/surplus. The question is whether government deficit/surplus (regardless of the GFSM definition) is indeed the best possible proxy for the theoretical concept of overall balance from the debt accumulation equation. To address this question, especially for the purpose of fiscal analysis, GFSM (2014) prescribes the definition of the "overall fiscal balance" as a fiscal indicator rather than accounting category. Formally, overall fiscal balance is defined as a "*net lending/net borrowing adjusted through the rearrangement of transactions in assets and liabilities that are deemed to be for public policy purposes (also called policy lending/borrowing*" (GFSM, 2014, pp. 83).

Following this definition, there is a recommendation to make a distinction between transactions in financial assets and liabilities depending on the purpose – whether they were acquired or disposed for public policy or liquidity management. While there is no clear rule how to make this distinction, general guidelines suggest that financial assets or liabilities acquired for the reasons such as supporting new industries, assisting public corporations, or helping troubled business sectors should be treated as public policy-related transactions. While theoretically accurate, the main issue in practical computation of this government operations' indicator is additional information requirement, since information from Statement of operations is insufficient to differentiate public policy-related from liquidity management transaction. Accordingly, literature on fiscal analysis is still using accounting definitions of government deficit/surplus (net lending/borrowing) as a measure of overall fiscal balance.

2.2.5 Borrowing requirements and debt funding strategy

It is clear from the previous discussion that government deficit/surplus (net lending/borrowing) as a result of the government operations represents a measure of the government financing needs, which in the literature are also called borrowing requirements. In the context of historical analysis, government deficit/surplus indeed depicts how much money the government can lend or must borrow to remain in fiscal equilibrium. Yet, when the debt accumulation mechanics is considered from the forward-looking point of view, two important practical issues emerged:

- How much money government really can lend or has to borrow, since a certain portion of debt falling due today needs to be refinanced tomorrow?
- If the government has to borrow, how it will fund lack of financial resources?

The corroboration of the former issue is given in Table 2.7, which shows the analytics of the gross borrowing requirements as a total of government financing needs. Gross borrowing requirements are defined as a "*net lending/net borrowing during a particular reporting period plus debt maturing within that reporting period*." (GFSM, 2014, pp. 83). In the context of fiscal sustainability analysis, debt maturing in a certain period is equal to the total debt redemptions, which needs to be refinanced in the next period, as illustrated below.

Table 2.7: Definition of the gross borrowing requirements

Revenues	T
Tax revenues	
Other revenues	
Expenditures	G
General expenditures	
Interest payments	
Budget deficit (BD)	T - G < 0
Budget surplus (BS)	T - G > 0
Total net borrowing requirement (NBR) = BD = [- (T-G)]	
Total Redemptions of:	
Short term debt	TR(ST)
Long term debt	TR(LT)
Total redemptions (refinancing requirement)	TR = TR(ST) + TR(LT)
Total gross borrowing requirement (GBR)	**GBR = TR + BD = TR + NBR** **GBR = TR - BS**

Source: *Blommestein et al. (2010), pp. 3*

From the historical point of view, gross borrowing requirements are less relevant fiscal indicator since the term, interest and currency structure of the liabilities incurred to fund government financing needs are already familiar information. From the forward-looking point of view, the gross borrowing requirements are crucial analytical input for the DMO, since DMO is legally empowered to manage public debt actively and thus to determine term, interest and currency structure of the liabilities that will incur to fund financing needs. In other words, the DMO anticipates gross financing needs for a certain period of time and makes funding strategy, i.e. decision what combination of debt instruments will be issued to close financing gaps. As defined by the OECD staff, "*The funding strategy entails decisions about how the borrowing requirements or needs are going to be financed (e.g. by using long-term bonds, short-term securities, nominal or indexed bonds, etc.). Clearly, total gross borrowing requirements should be the same as total expected or projected funding amounts.*" (Blommestein et al., 2010, pp. 3)

While debt accumulation mechanics explained by the equation (2.9) provides an important theoretical insight into the mechanics of debt formation over time, its application, in reality, is limited by two important issues. First, the DAE in (2.9) operates in terms of net borrowing requirements, which is not suited for the forward-looking analysis of debt dynamics in the case of DMO, which has authority to manage debt dynamics actively, including debt refinancing. Second, theory of debt accumulation is not particularly concern with "stock-flow" relationship between debt (stock variable) and interest payments/government balance (flow variables). Indeed, from the theoretical view, this is irrelevant issue, but it is clear that in practice there is a big difference in managing public debt on a short-term or long-term basis. Like any other strategic decision, debt funding strategy is planning document that covers time horizon of at least one year. In practice, the DMO staff anticipate the gross borrowing requirements for a certain period of time (one year) and then decide on type of instruments and its characteristics (maturity, interest rate, currency) aiming to optimize debt servicing costs/risks and ensure fiscal sustainability. The issues of public debt costs/risks optimization and fiscal sustainability assessment are discussed in the following chapters. In this subsection focus is on development of debt accumulation mechanics, which is more suited for practical assessment of forward-looking debt dynamics as a basis for making debt funding strategy.

Let's assume that DMO is analyzing possible debt funding strategies for the one-year period t. If the beginning of the period t is noted with t, b and end of the period with t, e, then mechanics of the debt accumulation imposes that anticipated closing value of the public debt at the end of the period $E\left(D_{t,e}^{*}\right)$ should equal the sum of existing debt at the beginning of the period $D_{t,b}^{EX}$ and anticipated value of the overall balance for the given period $E(OB_t)$,

$$E\left(D_{t,e}^{*}\right) = D_{t,b}^{EX} + E(OB_t). \tag{2.14}$$

The existing debt $D_{t,b}^{EX}$ consists of two components: the fraction of liabilities that will outstand by the end of the period $F_{t,e}^{EX,O}$ and a fraction of debt that will mature by the end of given period $F_{t,e}^{EX,M}$,

$$D_{t,b}^{EX} = F_{t,e}^{EX,O} + F_{t,e}^{EX,M}, \tag{2.15}$$

so equation (2.14) can be rewritten as

$$E\left(D_{t,e}^{*}\right) = F_{t,e}^{EX,O} + F_{t,e}^{EX,M} + E(OB_t). \tag{2.16}$$

To formalize connection of the borrowing requirements, debt funding strategy and debt accumulation mechanics, net borrowing requirements NBR_t and gross borrowing requirements GBR_t for the period t are defined and introduced to the DAE. Following the discussion on borrowing requirements, it is evident that NBR_t matches the anticipated value of overall balance at the beginning of the period, $NBR_t = E(OB_t)$, which can be further decomposed to a difference between projected interest payment on the existing debt

INT_t^{EX}, which are already projected by the DMO staff, and the anticipated value of primary balance $E(PB_t)$

$$NBR_t = -E(PB_t) + INT_t^{EX}. \tag{2.17}$$

On the other side, GBR_t matches sum of the anticipated value of overall balance/net borrowing requirements and existing debt maturing over the given period, which is also projected by the debt redemption plan,

$$GBR_t = F_{t,e}^{EX,M} + E(OB_t) = F_{t,e}^{EX,M} + NBR_t. \tag{2.18}$$

Accordingly, the anticipated value of public debt at the end of the period equals sum of existing debt outstanding by the end of given period and gross borrowing requirements

$$E\left(D_{t,e}^{*}\right) = F_{t,e}^{EX,O} + GBR_t. \tag{2.19}$$

To fund GBR_t, the government needs to either issue new debt or sell some financial assets. If only borrowing option is considered, then previous equation can be rewritten "terminologically" so that anticipated value of the debt by the end of period is decomposed more intuitively as a sum of "old", i.e. existing debt $D_{t,e}^{EX,O} = F_{t,e}^{EX,O}$ and increment of "new" debt $E(\Delta D_t^{NEW}) = GBR_t$ which will be issued to fund borrowing requirements and keep public finance in equilibrium,

$$E\left(D_{t,e}^{*}\right) = D_{t,e}^{EX,O} + E(\Delta D_t^{NEW}) = F_{t,e}^{EX,O} + F_{t,e}^{EX,M} - E(PB_t) + INT_t^{EX}. \tag{2.20}$$

What would happen if the DMO wants to forecast the dynamics of the public debt one period ahead? First, the outstanding value of existing debt at the end of period t (or beginning of the period $t+1$) is considered. A portion of this debt will mature over $t+1$, while the rest will outstand by the end of $t+1$,

$$D_{t+1,b}^{EX,O} = F_{t+1,e}^{EX,O} + F_{t+1,e}^{EX,M}. \tag{2.21}$$

Of course, $F_{t+1,e}^{EX,O}$ will continue to generate interest payments INT_{t+1}^{EX} over the period $t+1$. The same logic holds for the debt issued during the period t,

$$E(\Delta D_t^{NEW}) = E\left(F_{t+1,e}^{NEW,O}\right) + E\left(F_{t+1,e}^{NEW,M}\right), \tag{2.22}$$

under the reasonable assumption that portion of newly issued debt is short-term, i.e. maturing up to one year. Again, in the period $t+1$ government operations other than interest payments will generate primary balance PB_{t+1}, which can be only forecasted at t. The gross borrowing requirements for $t+1$ relative to the beginning of the period t then will then count as

$$GBR_{t+1} = INT_{t+1}^{EX} + F_{t+1,e}^{EX,M} - E(PB_{t+1}) + E\left(F_{t+1,e}^{NEW,M}\right) + E\left(INT_{t+1}^{NEW}\right), \tag{2.23}$$

and consequently forecasted value of public debt by the end of period $t+1$ equals portion of existing debt in t, b that will outstand at $t+1, b$, a portion of newly issued debt in t that will outstand at $t+1, b$ and gross borrowing requirements outstand at $t+1$

$$E\left(D_{t+1,e}^{*}\right) = F_{t+1,e}^{EX,O} + E\left(F_{t+1,e}^{NEW,O}\right) + GBR_{t+1}. \tag{2.24}$$

Using this pattern of forward-looking recursion, forecasts of the public debt dynamics can be extended beyond $t+1$ period.

To explain how the debt funding strategy is developed, let's assume that DMO optimizes funding of borrowing requirements over only two parameters: first, over term structure (to minimize exposure to interest rate/refinancing risks) and then over currency structure (to minimize exposure to foreign exchange rate volatility). The result of such optimization will be weights of each debt type in borrowing requirements over both parameters, $\omega_{j,t}^{TS}$ for the term structure and $\omega_{k,t}^{CS}$ for currency structure, such that

$$F_{k,j,t}^{NEW} = \omega_{k,t}^{CS} \omega_{j,t}^{TS} \, GBR_t. \tag{2.25}$$

Since the DMO aims to keep public finance in balance, $E(\Delta D_t^{NEW}) = GBR_t$, then a weighted sum of all newly issued debt instruments should equal anticipated debt increment

$$E(\Delta D_t^{NEW}) = \sum_{k=1}^{N_K} \sum_{j=1}^{N_J} F_{k,j,t}^{NEW} = \sum_{k=1}^{N_K} \sum_{j=1}^{N_J} \omega_{k,t}^{CS} \, \omega_{j,t}^{TS} \, GBR_t. \tag{2.26}$$

where N_K counts number of available currency options, N_J counts available maturity options, and $\omega_{k,t}^{CS}\omega_{j,t}^{TS}$ is a specific weight in GBR_t for each debt type regarding the combination of maturity and currency structure (*j*,*k*). For example, if government can borrow in local currency, EUR and USD ($N_K = 3$), and does not prefer maturities over 10 years $\left(N_J = 10\right)$, then there will be in total 30 options to issue debt instruments $\left(N = N_K * N_J\right)$ with respect to currency and maturity. Decisions about weights of each debt type to fund gross borrowing requirements with proper argumentations (regarding debt costs/risks optimization and fiscal sustainability) make the core of debt funding strategy.

2.3 Non-fiscal and fiscal determinants of the public debt

Since macroeconomic view on debt sustainability is more oriented toward relative (to GDP) than absolute indicators, the DAE can be rewritten in relative terms as

$$d_t^* = (1 + \Delta fx_t)\left(1 + i_t^f\right)\frac{D_{t-1}^f}{Y_t} + \left(1 + i_t^d\right)\frac{D_{t-1}^d}{Y_t} - pb_t, \tag{2.27}$$

where Y_t is a nominal GDP, d_t and pb_t are the values of debt and primary balance relative to GDP, respectively. Decomposition of nominal current GDP growth $(1 + g_t)$ to real growth contribution $(1 + rg_t)$ and inflation contribution $(1+\pi_t)$ (measured by the change of GDP deflator):

$$Y_t = (1 + g_t)Y_{t-1} = (1 + rg_t)(1 + \pi_t)Y_{t-1}, \tag{2.28}$$

then the DAE can be completely expressed in relative terms as

$$d_t^* = \frac{(1+\Delta fx_t)\left(1+i_t^f\right)}{(1+rg_t)(1+\pi_t)} d_{t-1}^f + \frac{\left(1+i_t^d\right)}{(1+rg_t)(1+\pi_t)} d_{t-1}^d - pb_t. \tag{2.29}$$

If lagged foreign debt to GDP ratio is expressed as a fraction of total public debt to GDP ratio, $d_{t-1}^f = \omega_{t-1} d_{t-1}$, then the previous equation can be rearranged to

$$d_t^* = \frac{1}{(1+rg_t)(1+\pi_t)} \left[d_{t-1} + \Delta fx_t\left(1 + i_t^f\right)\omega_{t-1}d_{t-1} + i_t^f \omega_{t-1} d_{t-1} + i_t^d (1 - \omega_{t-1})d_{t-1}\right] - pb_t. \tag{2.30}$$

The final step in decomposition of the DAE to regular debt-creating flows requires simplifying assumption on uniform interest rate, computed as weighted sum of foreign and domestic interest rates, $i_t = \omega_{t-1} i_t^f + (1 - \omega_{t-1}) i_t^d$. The additional simplifying assumption that i_t^f is approximately equal to i_t and a couple of arithmetic transformation gives debt accumulation decomposed to main debt-creating flows

$$d_t^* - d_{t-1} = \frac{i_t - \pi_t(1+rg_t) - rg_t + \Delta fx_t \omega_{t-1}(1+i_t)}{(1+rg_t)(1+\pi_t)} d_{t-1} - pb_t, \tag{2.31}$$

This equation unfolds fundamental regular sources of debt creation, and consequently, sources of systematic risks. The regular identified debt-creating flows can be further divided between

- **Automatic debt-creating flows** – debt increments driven by non-fiscal variables, i.e. which are not under control of fiscal policy;
- **Primary balance** – debt increment as a direct result of government operations other than interest payments, i.e., under control of fiscal policy.

In reality, equation and actual values of public debt are never in equilibrium, due to uneven and non-systematic changes of asset or liability positions in government balance sheet not included in primary balance by accounting standards. These one-off changes are known as debt-deficit or in more general sense "stock-flow" adjustments. The majority of debt-deficit adjustments (DDA) can be attributed to government fiscal operations and considered as fiscal drivers of public debt dynamics. Such kind of DDA is also "identified" debt creating flows, like privatization receipts or recognition of contingent liabilities activation. On the other side, unidentified DDA usually stems from some accounting mismatches (full discussion on debt-deficit adjustments is provided later in this section). Addition of debt-deficit adjustments dd_t (relative to GDP) gives final form of the DAE in terms of actual debt:

$$d_t - d_{t-1} = \frac{i_t - \pi_t(1+rg_t) - rg_t + \Delta fx_t \omega_{t-1}(1+i_t)}{(1+rg_t)(1+\pi_t)} d_{t-1} - pb_t + dd_t. \qquad (2.32)$$

From the debt accumulation equation (2.11) follows that debt increment over time is a function of four non-fiscal variables: interest rate, inflation, real growth rate and foreign exchange rate, and two fiscal variables: primary balance and debt-deficit adjustments, as it reads below:

$$\Delta d_t = f(i_t, \pi_t, rg_t, \Delta fx_t, pb_t, dd_t). \qquad (2.33)$$

2.3.1 Fiscal determinants of the public debt

Opposite to non-fiscal determinants of the public debt, which impact on the dynamics of public debt is proportional to past values of debt as follows from equation (2.32), fiscal determinants are direct contributors to the current value of public debt. In that sense, short-run transmission mechanics and direction of impact of fiscal determinants on debt are quite straightforward and stem directly from arithmetic in (2.32) equation, e.g. 3% surplus in primary balance to GDP (or in debt-deficit adjustment) reduce public debt to GDP at exactly 3%.

Primary balance

Nevertheless, things get less straightforward when dynamic aspects of the transmission mechanism between primary balance and public debt are scrutinized. This can be illustrated by the case in which the government is running an overall deficit over the prolonged period. When debt accumulation in absolute terms is considered (equation 2.6), it is clear that it will inevitably increase current level of debt in absolute terms. However, the DAE in relative terms (2.11) tells that if GDP grows at high rates, it can offset contribution of the overall fiscal balance to the debt increment. When GDP growth exceeds contribution of the overall deficit to the public debt dynamics, it is possible for government to stabilize long-term debt to GDP and achieve fiscal sustainability, even if it runs the deficit all the time. To corroborate this claim, the DAE representation in (2.9) is simplified by neglecting the real and nominal aspects of GDP growth and assuming that complete public debt is denominated in domestic currency (and thus exchange rate as a debt determinant can be omitted from the computations). After the simplification, the DAE reads as

$$d_t^* = \frac{(1+i_t)}{(1+g_t)} d_{t-1} - pb_t. \tag{2.34}$$

Furthermore, the latter equation can be rewritten in terms of debt increment Δd_t:

$$\Delta d_t = \frac{(i_t - g_t)}{(1+g_t)} d_{t-1} - pb_t, \tag{2.35}$$

to illustrate the point that public debt dynamics essentially depends on the values of primary balance and the difference between the nominal interest rate and nominal growth, which is known in the literature as the "interest-growth" differential.

The intention of the government to keep public debt to GDP ratio s basically means that public debt will be stabilized over time at some steady-state $\bar{d}$, $\bar{d} = d_t = d_{t-1}$, and the debt increment accordingly will equal zero, $\Delta d_t = 0$. If this assumption is made, it is possible to compute so-called "debt-stabilizing" primary balance $\overline{pb}_t$ that keeps public debt in steady-state equilibrium:

$$\overline{pb}_t = \frac{(i_t - g_t)}{(1+g_t)} d_{t-1}. \tag{2.36}$$

This equation tells particularly important aspects of the bi-directional causality in dynamic relation between the primary balance and public debt: while debt accumulation mechanics implies contemporaneous direct effect of primary balance on change in public debt, fiscal sustainability condition implies impact of lagged public debt on primary balance throughout the fiscal policy-making. In other words, public debt history is an important input of current fiscal policy stance.

Let's assume that fiscal authority computed value of debt stabilizing primary balance based on the previous equation and relevant inputs. An important question that arises inevitably is to what extent fiscal authority can really achieve targeted value of primary balance since primary balance in accounting sense represents the result of government operations other than debt servicing costs? Even on the intuitive level it is clear that pursuing exact value of primary balance is an extremely complex task since government needs to be in full control of its revenues and expenditures. On the other side, standard macroeconomic identities, such as those in IS-LM macroeconomic framework, considers government revenues as an endogenous variable, i.e. function of GDP. The exact value of the taxes and contributions eventually collected will depend on the respective accounting basis, which is in turn determined by the size of respective GDP components. Since the size of GDP in a market economy is driven by the economic fluctuations beyond government control, the best shot that government can do is to anticipate economic fluctuations as accurate as possible and to adjust primary balance according to anticipated fluctuations. Besides, some components of the government expenditures such as social transfers to unemployed are arguably associated with economic fluctuation and also needs to be taken into account to properly target specific value of primary balance.

In order to extend the analysis of the fiscal sustainability toward effects of the economic output fluctuations, primary balance can be further decomposed to the cyclically-adjusted primary balance (CAPB) and so-called “automatic stabilizers” as_t, as given below:

$$pb_t = capb_t + as_t. \qquad (2.37)$$

The cyclically-adjusted primary balance is interpreted as a value of primary balance that would be observed when the economic output is at potential value (Mourre et al., 2013). It depicts character of the discretionary fiscal policy and represents traditional measure of fiscal stance. On the other side, traditional measure of the economic cyclicality is output gap, which is defined as a difference between actual and potential value of economic output (GDP). In regard to the fiscal stance, fiscal policy can be considered as counter-cyclical if CAPB moves in the opposite way to economic cycle, for example if government increases CAPB during economic downturns when output gap goes bellow zero; the opposite holds for pro-cyclical fiscal policy, when CAPB moves in the same direction as output gap. The second component of the primary balance, automatic fiscal stabilizers, indicates the fraction of the primary balance directly influenced by cyclical fluctuations in the economy. More precisely, automatic stabilizers refer to fiscal categories that automatically react to the economic cycle without any intervention by fiscal policy authorities (Angelovska Bezovska et al, 2011).

In the older literature on fiscal policy, CAPB had been also called "structural" primary balance, but in recent years concept of structural primary balance has been further extended to adjust primary balance for transitory impacts other than economic cyclicality. The GFSM (2014) defines structural primary balance as "*primary fiscal balance, after removing the impact of cyclical movements in revenue, expenditure, and the effects of unusual or one-off events.*" (GFSM, 2014, pp. 83). In the context of fiscal policy analysis, use of structural policy as a measure of fiscal stance has obvious advantages relative to actual primary balance, as underscored by the Ademmer et al. (2016):

- Cyclicality of actual balance is significant because tax revenues are highly pro-cyclical, and social transfer payments (especially unemployment insurance payments) are counter-cyclical.
- During recessions, the actual balance deteriorates, even though this reflects neither short-term changes in policy nor long-term changes in fiscal sustainability
- One-off revenues or expenses are not the result of current policy, but instead the result of accounting decisions which do not reflect the current operations of the government

Since the CAPB (or structural PB) is arguably a more appropriate measure of fiscal policy stance than actual balance, the use of CAPB as a fiscal input in public debt sustainability analysis seems reasonable. The use of at least CAPB instead of actual is especially important in any kind of fiscal analysis over the period when economic fluctuations were pronounced, as in period surrounding global economic turmoil. The main problems with practical application of CAPB-based approach to fiscal sustainability are measurement issues; removal of the transitory components from the actual value of balance, as well as calculation of the potential GDP is not a trivial task. In recent years computation of CAPB/structural balance became the widespread practice of fiscal authorities, but methodology is still not unified. An illustration of comparative overview of the actual, primary and structural balance from Serbian Fiscal Strategy is presented in Table 2.8.

Table 2.8: Actual, cyclically-adjusted and structural values of primary balance, Serbia

	Output gap	Fiscal balance	Primary fiscal balance	Cyclical component of the fiscal balance	Cyclically adjusted fiscal balance	Cyclically adjusted primary fiscal balance	Structural primary fiscal balance**
2005	0.2	1.1	2.0	0.1	1.0	1.9	2.2
2006	-0.1	-1.5	-0.2	0.0	-1.5	-0.1	0.6
2007	1.5	-1.9	-1.3	0.6	-2.5	-1.9	-1.5
2008	3.9	-2.6	-2.1	1.5	-4.1	-3.5	-3.6
2009	-0.9	-4.4	-3.8	-0.3	-4.1	-3.4	-3.5
2010	-1.0	-4.6	-3.6	-0.4	-4.2	-3.2	-3.3
2011	0.1	-4.8	-3.6	0.0	-4.8	-3.6	-3.8
2012	-1.0	-6.8	-5.0	-0.4	-6.5	-4.6	-4.6
2013	1.3	-5.5	-3.1	0.5	-6.0	-3.6	-3.4
2014	-1.1	-6.6	-3.7	-0.4	-6.2	-3.3	-2.3
2015	-1.4	-3.7	-0.5	-0.5	-3.2	0.0	0.7
2016	-0.4	-1.3	1.8	-0.1	-1.1	1.9	2.0
2017	-0.8	0.7	3.4	-0.3	1.0	3.8	3.7
2018	-0.4	-0.7	1.9	-0.2	-0.5	2.0	2.0
2019	-0.3	-0.5	1.8	-0.1	-0.4	1.9	1.9
2020	0.2	-0.5	1.6	0.1	-0.6	1.5	1.5

Source: *Ministry of Finance, SRB (2017), pp. 69*

The methodological issues of potential GDP calculation and primary balance adjustment are discussed later in the text.

Debt-deficit adjustment

Debt-deficit adjustment (also known as stock-flow adjustment or reconciliation) measures the difference between overall fiscal balance and change in debt, which in theory should be equal according to the underlying macroeconomic identity of debt accumulation, as illustrated by equation (2.31). In reality, the sum of liabilities incurred never matches overall fiscal balance, i.e. net lending/borrowing as defined by GFSM (2014). The example of Croatian Statement of operations, given in Table 2.6, illustrates that point: according to the table, net borrowing in 2016 was 8,319,545,000 HRK, while amount of net liabilities incurred was 5,180,687, 000 HRK which means that 3,138,858,000 HRK of the overall balance was financed by the surplus in net acquisition of financial assets.

In terms of GFSM framework, OECD (2017) defines accounting identity that relates debt-deficit adjustment to other items from government finance statistics as follows: *debt-deficit adjustment = government balance + net purchase of financial assets - net incurrence of* *non-debt liabilities + revaluations of liabilities + other changes in the volume of liabilities*. The net acquisition of financial assets is usually the major component of the debt-deficit adjustment, but not the only one. In a more generic sense, debt-deficit adjustments reflect the difference between recorded fiscal balance and recorded government borrowing needs, and can be divided into three groups ECB (2014):

- Transaction in main financial assets – typically change of deposits held by the government or other public units which constitutes the general government sector;
- Time-of-recording differences – typically reflect mismatch in time recording of liability (being immediately recorded as an expenditure) and cash outflow of its payment (if delayed, reduce current borrowing requirements);
- Valuation effects – typically reflect market-to-face value adjustments between recording of debt at face value and financial transactions at market value.

In their paper, Hagen & Wolf (2006) cited the public finance circumstances that usually leads to discrepancy between the overall balance and debt increment:

- Issuance of zero-coupon bonds to cover deficit. If a bond that has a face value 150 EUR is issued at discount rate for 130 EUR to cover a deficit, the liability incurred (according to Maastricht definition) is recorded at nominal value of 150, so debt-deficit adjustment will be 20 EUR;
- Revaluation of debt denominated in foreign currency. The volatility of exchange rates changes the face value of the debt in foreign currency, without having any impact on the fiscal balance;
- A mismatch between a deficit that is measured in accrual terms and debt that is a cash concept. For example, if government sold some "doing business" licensees, this will count as revenue and reduce deficit in the year of selling, however, debt is only reduced when the cash receipts from selling licenses are used to terminate some liability.
- Privatization and equity injections in public companies.
- Transactions in financial assets. The selling of financial assets reduces gross debt, however, it has no effect on the fiscal balance when recorded by the EDP definition.

Within the GFSM framework, revaluation of liabilities is recorded under other economic flows. An example in Table 2.9 demonstrates the statistical treatment of refinanced debt which has been revaluated. In context of debt-deficit adjustment, case of public sector unit as a debtor is of particular interest. Since existing debt instrument of 100 was refinanced by new instrument of 95, existing liability of 100 is terminated and new liability incurred of 95 is recorded as financial transaction, while revaluation is recorded under other economic flows. Eventually, closing value of debt is 95, while revaluation value is considered as debt-deficit adjustment.

Table 2.9: Statistical treatment of debt revaluation

	Public sector unit as creditor				Public sector unit as debtor			
	Opening balance sheet	Trans-actions	Other economic flows	Closing balance sheet	Opening balance sheet	Trans-actions	Other economic flows	Closing balance sheet
Revenue								
Expense								
Net worth / Net operating balance	*100*	*0*	*–5*	*95*	*–100*	*0*	*5*	*–95*
Nonfinancial assets								
Net financial worth / Net lending (+) / net borrowing (–)	*100*	*0*	*–5*	*95*	*–100*	*0*	*5*	*–95*
Financial assets Existing debt instrument New debt instrument	100 100 0	0 –95 95	–5 –5	95 0 95				
Liabilities Existing debt instrument New debt instrument					100 100 0	0 –95 95	–5 –5	95 0 95
Gross debt Net debt	0 –100	0 0	0 5	0 –95	100 100	0 0	–5 –5	95 95

Source: *Task Force on Finance Statistics (2013), pp. 57*

Since its components are the result of government operations, debt-deficit adjustment can be clearly considered as a fiscal determinant of the public debt dynamics. As long as the DDA and its components are the result of sound statistical recording and can be clearly attributed to the results of the government operations, the reliability of deficit and debt records is not a subject of concern. For example, the IMF methodology of debt sustainability analysis makes a difference between identified and residual components of debt-deficit adjustment, whereby identified are further grouped into the privatization receipts, change in governmental deposits, contingent liabilities and net lending outside budget, while residual includes changes in assets.

If the components of debt-deficit adjustments are not a result of some intentional fiscal activity, these should tend to cancel out over time. Indeed, Table 2.10 shows that average DDA per annum in most Euro area countries was less than 1 percentage point over the period 1999 – 2006.

Table 2.10: Debt-deficit adjustments in Euro area 1999-2005

(annual average as a percentage of GDP)

Countries	DDA	Financial investment								Valuation & volume effects		Time of recording differences[1)]
			Currency and deposits	Securities	Shares				Loans		Change in volume of debt	
						Equity injections	Other investment in shares	Privatisations				
BE	0.2	-0.3	0.1	0.0	0.0	0.1	0.0	-0.2	-0.4	0.2	0.2	0.3
DE	-0.3	-0.3	0.0	0.0	-0.2	0.2	0.0	-0.4	-0.1	-0.1	-0.1	0.1
IE	1.6	0.7	0.5	0.2	-0.1	1.1	0.0	-1.3	0.2	0.6	0.0	0.2
GR	3.2	0.6	0.2	0.0	0.4	0.3	0.9	-0.7	0.0	0.9	0.0	1.7
ES	0.8	1.0	0.8	0.1	-0.1	0.2	-0.3	0.0	0.2	0.0	0.1	-0.3
FR	0.6	0.5	0.1	0.0	0.4	0.1	0.5	-0.2	0.0	0.1	0.1	0.0
IT	0.0	0.0	0.1	0.0	-0.4	0.1	0.1	-0.6	0.3	-0.5	0.0	0.5
LU	2.6	2.8	2.0	0.5	0.3	n.a.	n.a.	n.a.	-0.1	0.1	n.a.	-0.2
NL	0.0	-0.2	0.1	0.0	-0.2	0.0	0.0	-0.3	-0.1	0.1	0.0	0.1
AT	0.9	1.1	0.2	0.3	0.1	n.a.	n.a.	n.a.	0.6	-0.4	n.a.	0.1
PT	0.6	0.2	-0.1	0.2	-0.1	0.5	0.1	-0.7	0.2	-0.1	0.0	0.5
FI	4.5	4.2	0.7	2.6	1.1	0.1	2.3	-1.3	-0.2	0.4	-0.1	-0.1
Euro area[2]	0.3	0.2	0.2	0.1	0.0	0.2	-0.1	-0.4	0.1	-0.1	0.0	0.2

Source: *ECB (2007), pp. 91*

Large and persistent DDA that have a negative impact on debt developments may give cause for concern since it can be the result of the incorrect recording of government operations and in turn can lead to large ex-post upward revisions of deficit levels (EC, 2003). However, this is not always the case: exceptionally large levels of DDA in Luxemburg and Finland stemming from the financial investment that reads in Table 2.10 reflects accumulation of assets in social security funds to prepare for anticipated implicit contingent liabilities imposed by future pension payments (ECB, 2007).

2.3.2 Non-fiscal determinants of the public debt

The first step in the elaboration of the non-fiscal impact on public debt dynamics is distinction between real and monetary public debt drivers since these variables are very different with respect to the underlying fundamentals. While a value of GDP is determined by the utilization of domestic production function factors (labor, capital, technology and natural resources) and global economic cyclicality, inflation, exchange rates and interest rates are variables predominantly determined by the result of the domestic monetary operations and spillovers from international financial markets. In this subsection I analyze transmission mechanics in which non-fiscal determinants affect public debt dynamics, with specific focus on the intertwining between monetary public debt drivers.

Interest rate(s)

The simplified version of the DAE representation (2.7) in absolute terms shows that public debt dynamics are nominally driven by only two determinants: interest expense INT_t and primary balance PB_t (currency structure of debt portfolio is neglected). Since $INT_t = i_t D_{t-1}$, as given in (2.8), impact of interest rate on public debt in nominal terms seems pretty straightforward: increase in nominal interest rate leads to proportional increase in nominal public debt D_t.

Nevertheless, the main analytical issue of such approach to debt dynamics analysis in practice is a lack of natural "single" interest rate that can be applied to the aggregate value of lagged public debt to compute directly aggregate value of interest expense. Indeed, in reality interest expense INT_t on aggregate level is nothing else but a sum of the interest payments of the particular debt instruments $INT_t = \sum_{i=1}^{N} INT_{i,t}$. If currency structure of debt portfolio is also considered, under the restrictive assumption that domestic and interest rates are equal, interest payment for any instrument in a debt portfolio will be determined by the respective nominal interest rate and currency depreciation, $INT_{i,t} = f_i\left(i_{i,t}, \Delta fx_{i,t}\right)$. Furthermore, any nominal interest rate can be further decomposed to real interest rate and inflation rate using the famous Fisher formula:

$$\left(1 + i_{i,t}\right) = \left(1 + ri_{i,t}\right)(1 + \pi_t) \tag{2.38}$$

where $ri_{i,t}$ denotes real interest rate of debt instrument i. If a product od $ri_{i,t}$ and π_t is arguably considered to be very small values, the Fisher equation can be simplified and reads as $i_{i,t} \approx ri_{i,t} - \pi_t$. Besides, any real interest rate for particular debt instrument can be decomposed to the real "risk-free" interest rate rz_t, (usually measured by the real interest rate on T-bills), and risk premium $rpm_{i,t}$ that depends on specific riskiness of given instrument (which in case of Government predominantly represents maturity risk premium)

$$ri_{i,t} = rz_t + rpm_{i,t} \tag{2.39}$$

Taking everything into account, aggregate interest expense of public debt can be considered as a function of risk-free interest rate, set of respective N risk premiums, set of Q nominal depreciations (Q counts for currencies of denominations present among debt instruments), and inflation rate,

$$INT_t = f\left(rz_t; \{rpm_{i,t}\}_N; \{\Delta fx_{j,t}\}_Q; \pi_t\right) \tag{2.40}$$

From the previous, it is clear that no uniform natural interest rate can reflect such complexity of underlying factors that determine interest rate expense. Thus, in analysis of dynamic relations between public debt and interest rate(s) two options are possible:

1. Use of implied interest rate. A simple workaround consists of computing the so-called "implied" interest rate by dividing the current interest payment with the stock of outstanding debt from the previous period. Such practice is typically applied in macroeconomic type of fiscal sustainability analysis. This approach brings about a couple of advantages. First, it is very simple to apply and it does not require data on individual interest rates, maturity or currency structure of the debt. Second, the implied interest rate reflects influence of both interest rates and exchange rates on the pace of change in interest expense. Third, its application allows that aggregate interest expense from national accounts' statistics directly enters as an input to the debt accumulation equation. The main disadvantage of this approach, of course, is impossibility to explicitly discriminate contribution of particular interest and exchange rates' changes to debt increment. Implied interest rate r_t is simply computed as:

$$r_t = \frac{INT_t}{D_{t-1}} = f\left(rz_t; \{rpm_{i,t}\}_N; \{\Delta fx_{i,t}\}_Q; \pi_t\right) \tag{2.41}$$

and clearly it is a function of all aggregate interest expense' drivers.

2. Use of individual interest rates. Such an approach is "bottom-up" type, which means that individual interest rates are applied to individual instruments to compute individual interest payments, which are summed up to compute aggregate interest expense:

$$INT_t = \sum_{i=1}^{N} i_{i,t} \Delta fx_{i,t} F_{i,t-1} \tag{2.42}$$

Consequently, it is computationally extensive and requires very detailed information about the structure of debt and related interest rates. Despite these limitations, it is frequently used by public debt portfolio managers in cost/risk optimization analysis, especially in countries with developed financial markets and statistics. When applied to fiscal sustainability analysis, this approach is usually simplified, wherein simplification is achieved throughout grouping similar types of debt instruments into public debt sub-portfolios.

Exchange rate(s)

The impact of exchange rate depreciation (or appreciation) on public debt dynamics is quite similar in case of interest rate. From the DAE nominal representation in (2.9) directly follows that nominal depreciation leads to proportional increase in nominal value of public debt over two channels: value of those outstanding liabilities and those current interest payments, which are denominated in foreign currency; both of them get more expensive if valuated in local currency units. If the cost of depreciation is denoted as FXC_t and portion of debt in foreign currency as D_t^f, under the assumption that domestic and foreign nominal interest rates are equal, cost of depreciation equals sum of these two components

$$FXC_t = \Delta fx_t D_{t-1}^f + \Delta fx_t i_t D_{t-1}^f \tag{2.43}$$

In case the public debt portfolio comprises debt instruments denominated in different currencies, it is impossible to have single measure of aggregate nominal depreciation. On the portfolio level, the aggregate value of the cost of depreciation equals sum of individual costs, $FXC_t = \sum_{q=1}^{Q} FXC_{q,t}$. Consequently, cost of depreciation will be a function of uniform nominal interest rate and a set of Q nominal depreciations.

For the purpose of exchange rate forecasting, which is an important issue for estimation of the future debt servicing costs, essential question is what determines its dynamics. The standard macroeconomic theory relies on three important concepts to explain how exchange rates interact with monetary variables:

1. Law of One Price and Purchasing Power Parity (PPP)
2. International Fisher Effect (IFE)
3. Uncovered Interest Rate Parity (UIP)

1. The fundamental theory about relations between prices and nominal exchange rate, known as the Law of One Price, suggests that on the perfect markets price of any good in domestic country should be equal to a product of nominal exchange rate and price of this good in foreign country, otherwise there will be opportunity for trading arbitrage. For instance, if the price of 1kg tomato costs 1.5 EUR in some EU countries and RSD/EUR exchange rate is 120, then price of 1kg tomato in Serbia should be equal 180 RSD. If price of 1kg tomato in Serbia is 200 RSD, one can purchase tomato in EU, sell in Serbia and makes arbitrage (risk-free) profit of 20 RSD per kg of tomato. The direct consequence of the Law of One Price is equality of purchasing powers among currencies, underpinning the popular concept of absolute Purchasing Power Parity (PPP). Thus, nominal exchange rate

can be thought of as a relationship between average price level in domestic country P_t^d over average price level in foreign country P_t^f:

$$fx_t^{PPP} = \frac{P_t^d}{P_t^f} \tag{2.44}$$

where superscript *PPP* denotes the theoretical value of exchange rate if the PPP hypothesis holds. Consequently, average domestic price level is equal to a product of nominal exchange rate and average price level in foreign country, $P_t^d = fx_t^{PPP}{}_t P_t^f$. The concept of absolute PPP is considered too restrictive since the weights and basket of goods used in the computation of the average price level differs across countries. Instead, less restrictive concept of relative PPP appears as more realistic; according to relative PPP, nominal exchange rate depreciation[14] equals ratio between domestic and foreign index general price index

$$\Delta fx_t^{PPP} = \frac{(1+\pi_t^d)}{(1+\pi_t^f)} - 1 \approx \pi_t^d - \pi_t^f \tag{2.45}$$

In a simplified version, relative PPP equals inflation differential between domestic and foreign inflation, with straightforward interpretation that higher rate of domestic relative to foreign inflation has to be offset by nominal depreciation of exchange rate in order to preserve equality of purchasing powers.

2. If the relative PPP holds, the Fisher equation in (2.38) can be further extended to include exchange rate. Based on a simplified version of the Fisher equation, the inflation rate can be approximated as a difference between nominal and real interest rates, $\pi_t \approx i_t - ri_t$. If the capital markets are assumed to be perfectly mobile, then real interest rates among countries will be arguably equal. If the approximated value of inflation is inserted into equation of relative PPP (2.45), it follows that

$$\Delta fx_t^{PPP} = (i_t^d - ri_t) - (i_t^f - ri_t) = i_t^d - i_t^f. \tag{2.46}$$

The hypothesis that differences in nominal interest rates reflect changes in exchange rates, is known as the International Fisher Effect.

[14] For the sake of terminological simplicity, depreciation in this text generally refers to a change in exchange rate, whilst depending on the direction of change it can be appreciation as well.

3. The theory of interest rate parity represents in some way generalization of the IFE hypothesis, with an emphasis on forward-looking aspects. The IFE as specified in (2.46) operates with nominal interest and exchange spot rates in continuous framework, neglecting that in reality exchange rate depreciation is measured over a discrete period of time, as well as discrete nature of interest rate term structure. On the other side, the UIP as a basic interest rate parity concept formalizes relationship between maturity of interest rates and the period of exchange rate depreciation. If the term structure is added to analytical framework, nominal spot interest rate becomes a function of its maturity noted as j, $i_{j;t} = f(j)$. For the sake of simplicity, let's assume that analysis is limited to 1-year spot interest rate $i_{1;t}$. In that case, the UIP principle requires that expected debt servicing costs on 1-year loan should not depend on the currency of borrowing. If expected exchange rate depreciation over one year is noted as $E(\Delta fx_{1;t})$, than the UIP in quantitative terms reads as:

$$\left(1 + i_{1;t}^{d}\right) = \left(1 + E\left(\Delta fx_{1;t}\right)\right)\left(1 + i_{1;t}^{f}\right). \qquad (2.48)$$

The notion of the UIP is stemming from the assumption on the perfect mobility of capital and no-arbitrage principle: a debtor should be indifferent today between borrowing in domestic currency at rate $i_{1;t}^{d}$ or borrowing in foreign currency at the rate $i_{1;t}^{f}$ regardless of the spot exchange rate, since expected depreciation one-year ahead will equal debt servicing costs in both currencies.

The validity of PPP and UIP remains one of the most debated concepts in economic literature. When absolute PPP is considered, it is reasonable to expect that it has failed empirical testing; apart from abovementioned inconsistency in measuring average price level across countries, absolute PPP relies on assumption of free trading on perfect markets. In reality, of course, vast majority of free trade and market failures, like import and export duties, imperfect competition (monopolies, price differentiation), existence of non-traded goods (like housing) or local consumers' preferences result in country-specific price distortions that leads to violations of absolute PPP. However, empirical studies also provided a lot of evidence that nominal depreciation tends to deviate from inflation differential, especially in the short run, while in the very long run relative PPP is found to be more consistent with empirical data. 2.11 shows example of long-run relationship between USD/EUR actual and PPP exchange rates, illustrating short- and mid-term deviations of the PPP from actual exchange rates.

Figure 2.11: Actual USD/EUR and PPP exchange rates
Source: *Bekaert & Hodrick (2018)*

Proponents of the PPP develop an exchange rate model based on PPP and general monetary approach, which strives to explain how monetary variables explain long-term adjustments of the exchange rates. The underlying idea is that price level in some countries reflects relationship between money supply and money demand. While money supply M^S is exogenous variable, money demand M^L is a function of nominal interest rate and economic output Y, $M^L = M^L(i, Y)$. Additionally, from the Fisher equation given in (2.38) follows that nominal interest rate depends on inflation. The average price level then reads as

$$P_t = M_t^S / M_t^L(i_t(\pi_t), Y_t) \qquad (2.49)$$

since the monetarist approach assumes that in the long-run inflation has no effect on economic output. Having this representation of price levels, nominal exchange rate can be expressed in terms of domestic and foreign money supplies:

$$fx_t^{PPP} = \frac{M_t^{S,d} / M_t^{L,d}(i_t^d(\pi_t^d), Y_t^d)}{M_t^{S,f} / M_t^{L,f}\left(i_t^f\left(\pi_t^f\right), Y_t^f\right)} \qquad (2.50)$$

From the previous equation follows that monetary factors have the subsequent long-term impact on nominal exchange rate depreciations:

- Money supply: a shock in the domestic (foreign) money supply causes proportional depreciation (appreciation) of exchange rate;
- Nominal interest rate: a shock in the domestic (foreign) interest rate causes a fall in domestic (foreign) money demand and a subsequent depreciation (appreciation) of exchange rate. Additionally, prolonged money supply growth will result in inflation, which in turn will increase nominal interest;

Because of the widespread empirical corroboration of the PPP hypothesis's failure, more general approach to exchange rate theory is proposed, to support view that deviations of the actual from equilibrium PPP values can be long-term outcomes. Such a generalized monetary approach introduces a concept of real exchange rate rfx_t, which enters into absolute PPP equation (2.44) as given

$$fx_t = rfx_t \frac{P_t^d}{P_t^f} = rfx_t fx_t^{PPP}. \tag{2.51}$$

The real exchange rate reflects persistent deviations between actual PPP exchange rates. If equation (2.51) is rearranged as

$$rfx_t = fx_t \frac{P_t^f}{P_t^d}, \tag{2.52}$$

real exchange rate can be understood as a ratio between the value of foreign consumption basket expressed in domestic currency over the value of domestic consumption basket. In other words, it reflects at which rate foreign consumption basket can be traded for domestic consumption basket in terms of real purchasing power. From the latter it is stemming that real exchange rate is a function of relative demand for domestic and foreign goods; for example, if the demand for domestic products goes up, the real exchange rate will appreciate and *vice versa*. When the monetary approach is integrated with concept of real exchange rate, then three possible situations in which real factors impact nominal exchange rate can be identified:

- Increase in demand for domestic output: since both domestic output Y_t^d and foreign output Y_t^f do not change, price levels also do not change (as reads from equation 2.49 and 2.50), so the nominal exchange rate will appreciate following appreciation of real exchange rate.
- Increase in demand for foreign output: since the price levels will not change, nominal exchange rate will depreciate following the depreciation of the real exchange rate.

- Increase in supply for domestic output: the real exchange rate will depreciate, but rise in domestic output will reduce domestic price level through increase in money demand (equation 2.49) and fx_t^{PPP} will depreciate (equation 2.50). The overall effect will be ambiguous. The same prediction of ambiguous overall effect holds for change in supply of foreign output.

Summarizing previous discussion, two important conclusions about nominal exchange rate dynamics arise:

- If the PPP is assumed to hold, dynamics is utterly explained through foreign exchange rate adjustments to monetary factors: according to the relative PPP, nominal depreciation is a function of domestic and foreign inflation, $\Delta fx_t = f\left(\pi_t^d, \pi_t^f\right)$, while according to the IFE and the UIP, nominal depreciation is a function of domestic and foreign interest rates, $\Delta fx_t = f\left(i_t^d, i_t^f\right)$;
- If the PPP is not assumed to hold, dynamics is explained both through the change of real exchange rate and change in relative prices (that reflects depreciation of PPP nominal exchange rates), $\Delta fx_t = f(\Delta rfx_t, \Delta fx_t^{PPP})$.

Economic output

Use of GDP as an aggregate measure of economic output has become universally accepted worldwide, but scope of covered economic activities and accounting standards of GDP computation may differ between countries. As of 2018, EU countries count GDP according to ESA 2010 accounting standards, and GDP data from earlier years, based on ESA 95, have been adjusted to match new standards, too. Since ESA 2010 is obligatory for EU countries, Serbian Statistical Office has recently aligned national accounting with ESA 2010 and quarterly series of GDP data are revised back to 2006.

In the subsection about primary balance as a public debt dynamics determinant, the importance of the potential GDP for the proper determination of the fiscal policy stance has been emphasized. The potential GDP is theoretical concept and its quantification is not a trivial task – it depends on understanding what the term “potential” means. In the broadest sense, potential GDP reflects the idea of the efficient frontier of production function and can be thought as the level of output produced when workforce is fully employed and its capital stock is fully utilized. The phrase “fully employed workforce” in potential GDP definition does not have literal meaning, but rather that level of unemployment is reduced down to so-called natural rate of unemployment, in line with famous Okun’s Law that links output gap and unemployment gap. In that manner, actual economic output can be considered as a function of potential GDP, which reflects inner productive capacities of the economy, and output gap that in modern globalized economic environment reflects economic fluctuations which is usually driven by global cyclicality:

$$Y_t = f(Y_t^p, og_t) \tag{2.53}$$

Yet, estimation of the potential GDP using production function theory and macroeconomics laws is quite demanding activity even for international organization such as the IMF or FED, thus there is a widespread practice of backward-looking estimation of the potential GDP by smoothing and extracting trends from GDP historical data. The basic idea of computing potential GDP as a smooth trend of actual GDP time series relies on state-space modeling. State-space models are class of statistical models that represents some actual variable as a sum of unobserved components which are driven by stochastic processes. Consequently, economic output as an observed variable can be decomposed to sum of three unobserved components: trend, cyclical variations and seasonal variations, as given in the equation bellow (Hindrayanto et al., 2014):

$$Y_t = \tau_t + c_t + s_t, \tag{2.54}$$

where y_t stands for economic output, τ_t for trend and c_t, s_t and v_t for cyclical, seasonal and irregular variations, respectively. In state-space terminology, this equation is called measurement equation, in which observed variable is decomposed into unobserved components (state variables). If each of the state variables follow some autoregressive stochastic process of the first order, than their joint dynamics can be depicted by the following equation,

$$Z_t = TZ_{t-1} + w_t, \tag{2.55}$$

where z_t is a vector of unobserved components, T is a transition matrix and w_t is random error which is usually assumed to be identically independently normally distributed variable, $w_t \sim IIDN(0, \Sigma_{ww})$. This equation is called transition equation.

Of course, there is an issue how to estimate vector of unobserved components z_t and transition matrix T which describes evolution of state variables. The frequently used solution of this problem, proposed by Kalman (1960), use procedure of linear filtering that consists of four steps: initialization, prediction, correction and likelihood construction. Then T and z_t (including trend component that represents potential economic output) can be estimated by maximizing constructed likelihood function using numerical optimization, since there is no analytical solution to this problem. For more details on Kalman procedure, see for example Pichler (2007).

Beside Kalman filtering, another popular solution to computation of potential GDP based on state-space representation of economic output was proposed by Hodrick and Prescott (1997), which is known in the literature as HP filtering. HP filtering is based on the following state-space representation of the economic output (Cardamone, 2016):

$$Y_t = \tau_t + c_t; \\ \tau_t = 2\tau_{t-1} - \tau_{t-2} + w_t. \tag{2.56}$$

Since transition coefficients are predetermined in HP state equation, the simple HP filter gives an estimate of the unobserved variable as the solution to the following minimization problem:

$$min \sum_{t=1}^{T} (Y_t - \tau_t)^2 + \lambda \sum_{t=2}^{T-1} [(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})]^2 \tag{2.57}$$

where λ is a smoothing parameter that defines smoothness of the trend and depends on the data frequency of the time series.

2.4 Public debt sensitivity to macroeconomic shocks

In most general sense, sensitivity analysis is an analytical tool that quantitatively appraises how much value of some economic variable will change if value of one or more of its determinants change. Since the fiscal sustainability analysis is a forward-looking concept, sensitivity of the public debt to changes in its determinants makes the crucial aspect of the sustainability assessment. While existing literature and debt management practice propose a vast number of possible approaches to analysis of pubic debt sensitivity to macroeconomic shocks, the most important aspects that should be taken into account to set up adequate analytical framework can be roughly condensed in two crucial dimensions:

- Calibration of the shocks: whether the shocks are calibrated arbitrary or based on some quantitative modeling?
- Spillover of the shocks: whether a shock in one debt driver affects public debt independently or throughout interaction with other debt drivers?

It is intuitively clear that public debt sensitivity analysis is more complex and computationally extensive in case when shocks are calibrated based on quantitative modeling and/or when a shock in one determinant affect values of other variables, relative to case when shocks are arbitrary calibrated and/or when impact of a shock in one determinant is isolated from other determinants. Since the objective of this subsection is introduction to the basic elements and issues of debt sensitivity analysis, here I focus on the practices of the arbitrary calibration and isolated shock impacts, while the issues of model-based calibration and shock' spillovers are discussed in the subsequent chapters. For this purpose, the IMF DSA Debt Sustainability Assessment (DSA) methodology was used as an illustrative example of the arbitrary calibrations of the shocks. The DSA has been routinely exercised by the IMF country teams and reported in respective country reports. In 2013, DSA methodology was upgraded to deal with interdependency of the public debt determinants, but former versions were based on the debt sensitivity analysis with respect to isolated shocks.

2.4.1 Arbitrary calibration of the shocks

A colloquial term "shock" in macroeconomics usually evokes unanticipated, sudden, temporary and sharp rise or fall in some variable, that has detrimental impact on the anticipated values of other variables and macroeconomic equilibrium. In that context, idea of macroeconomic shocks implies existence of so-called "baseline" scenario, which refers to the expectations and anticipations about the most probable development of the macroeconomic variables over certain period of time. However, in more general sense shock does not necessary need to be neither temporary, sharp, detrimental, nor completely unanticipated or sudden. What is of the utmost importance to declare some change in variable as a "shock" is that such change reflects **deviation from its baseline forecast**. Thus, arbitrary calibration of the shock is nothing else but making assumptions how much value of certain variable will deviate relative to its baseline expectation, and against which sensitivity analysis will be applied. If the shock is calibrated arbitrary, size of this deviation is primarily set based on some form of subjective reasoning, conjectures, beliefs or sentiments.

Framework of arbitrary shock analysis is usually implemented in deterministic manner, meaning that shock in some variable is specified by three parameters: i) size; ii) direction; iii) length of duration and frequency of occurrence.

1. Size of the shock. It's intuitive that direction of the shock is determined to be detrimental (but not necessary), since analysts are primarily interested in worse case scenario. Size of the shock may be specified with respect to baseline referent value of given determinant in the following ways:

- as a percentage change, for example 10% increase in primary balance;

- as a change in percentage or basis points, for example increase in interest rates for 2 percentage points;
- as a fraction of dispersion measure of determinant variable volatility over certain period, typically standard deviation (which is special case of previous specification), for example fall in GDP for one standard deviation of the GDP dynamics in last 10 years.

Since determinants within debt sensitivity analysis framework are measured in percentages, either as rates (interest rate, GDP growth rate, depreciation of exchange rate) or proportions (primary balance to GDP), it is very important to be precise when defining and interpreting a size of shock. In case of primary balance, one possibility is to define size of shock as a percentage change, e.g. 25% growth of PB/GDP ratio, relative to some baseline value. If, fore example, baseline value is 3%, then value of the "shocked" variable will be 3.75%. This corresponds to definition of size of shock as 75 basis points increase in PB/GDP baseline value.

2. Direction of the shock. when sensitivity analysis is performed, analyst is usually interested for adverse shocks, and the type of shock is determined by its direction. If shock is defined in relative terms as percentage increase of some referent value, one should be careful about a sign of the baseline value. In other words, if shock is defined as percentage change of baseline value, it can result in shock with unwanted direction. For instance, if baseline value of depreciation is -10% (i.e. 10% appreciation), then shock defined as 25% of the baseline value will actually result in -2.5% size of shock which is not adverse in terms of impact on debt dynamics. In order to avoid confusion, popular choice is to state size of shock as a fraction of standard deviation, as its value is always positive, and then to give appropriate sign. This procedure is also backed up by economic and statistical reasoning, as the standard deviation is the most correct measure of random variable dispersion and compatible with size of the average.

3. Adjustment of the shock to the length of duration and frequency of occurrence. Generally speaking, shock can be related to one specific period in time or to time span of several consecutive periods. Accordingly, size of shocks could be treated as temporary or persistent, which accumulates over time. For instance, permanent annual increase in inflation rate of 2.5 percentage points over the period of 5 years will result in size of accumulated shock for approximately 12.5 percentage points over the whole period. The preferred size of accumulated shock has to be aligned with time frequency of the data analyzed, too. For example, if the shock in exchange rate is specified as 25% annually and applied to quarterly data, it does not mean that that exchange rate will depreciate for 25% regarding the value of real exchange rate from previous quarter, but from the value of respective quarter one year ago.

One example of the arbitrary shock calibrations in the context of debt sensitivity analysis, based on former IMF DSA methodology, is presented in Table 2.11.

Table 2.11: The IMF DSA scheme of arbitrary calibrated shocks

Alternative scenarios (A1-A2) *Permanent shock over the entire projection period*	**A1. Historical** *Key variables are at their historical averages* **A2. Primary balance** *No policy change (constant primary balance)*	**Bound tests (B1-B5)** *Temporary shocks*	**B1. Real interest rate** *Real interest rate is at baseline plus certain fraction of standard deviation* **B2. Real GDP growth** *Real GDP growth is at baseline minus certain fraction of standard deviation* **B3. Primary Balance** *Primary balance is at baseline minus certain fraction of standard deviation* **B4. Combination of B1-B3** *Each reduced only by certain fraction of standard deviations.* **B5. Depreciation** *One-time nominal depreciation of certain percent*

Source: *Summary of DSA assessment from various country reports*

As seen from the table, if the shocks are considered in the most general sense as any deviation from the baseline, two types of the debt sensitivity analysis can be performed:

Scenario analysis. Scenario analysis can be thought of as the most generic framework to assess expected outcomes of some economic activity under the scenarios alternative to baseline case. The coverage of "shocked" variables within given scenario can vary, from only one up to all relevant determinants. In case of the IMF DSA debt sensitivity, scenario analysis considers future debt outcomes in cases of macroeconomic forecasts being alternatives to the baseline scenario, not necessary detrimental as the alternatives can be also optimistic. Some of the possible alternatives "historical scenario", in which debt determinants are conjectured at their historical averages, or so-called "no fiscal policy change" in which primary balance is kept constant and equal to last recorded actual value. In such kind of alternative scenarios, shocks are permanent in nature.

Stress testing. Stress testing is a standard risk management tool applied in many areas of financial and economic analysis, the most notably in banking risk management. Stress testing can be thought of as a special case, i.e. "worst case" scenario analysis, which examines what would happen with given economic variable if one ore more of its determinants take extremely unfavorable value in the near future. The IMF DSA stress testing analysis, also known as "bound tests", applies one ore two arbitrary calibrated temporary shocks to debt sensitivity analysis.

2.4.2 Public debt sensitivity to isolated shocks

As being said earlier, impact of a shock in one determinant on public debt can be considered as isolated, i.e. independent from other debt determinants, or alternatively throughout the possible spillover to other determinants (under assumption that debt determinants are interdependent), which in turn change their values relative to anticipated baseline scenario and thus additionally affects public debt. The previous discussion about public debt determinants points out existence of their interdependence, dismantling realism of the isolated shock conjecture. However, simplicity of isolated shock approach makes it very useful to get intuition of the public debt sensitivity, while due to low data and computational requirements such approach is still very popular choice among economic analysts.

The convenient way to start discussion about sensitivity of public debt to macroeconomic shocks is more general sense is to make further decomposition of automatic debt-creating flows to particular contributions of real interest rate, real GDP growth and exchange rate as follows, based on the DAE representation in relative terms (2.32) and the IMF DSA methodology:

1) Real interest rate contribution (RIRC) to change in public debt, as a function of nominal interest rate, inflation, real growth and lagged debt:

$$RIRC_t = \frac{i_t - \pi_t(1+rg_t)}{(1+rg_t)(1+\pi_t)} d_{t-1}; \qquad (2.58)$$

2) Real GDP growth contribution (RGC) to change in public debt, as a function of real growth, inflation and lagged debt:

$$RGC_t = \frac{-rg_t}{(1+rg_t)(1+\pi_t)} d_{t-1}; \qquad (2.59)$$

3) Exchange rate depreciation contribution (ERDC) to change in public debt, as a function of nominal exchange rate, interest rate, share of debt in foreign currency, inflation and lagged debt:

$$ERDC_t = \frac{\Delta f x_t \omega_{t-1}(1+i_t)}{(1+rg_t)(1+\pi_t)} d_{t-1}. \qquad (2.60)$$

On the other side, according the relative DAE (2.32) contributions of the fiscal determinants PB/GDP and DDA/GDP are straightforward: change of PB/GDP or DDA/GDP in x% results in change of debt to GDP for exactly x%. Using such approach, historical path of public debt can be decomposed to fiscal and non-fiscal contributors. Decomposition of the Serbian public debt (Maastricht definition) on quarterly data for 2017-2018 is presented in Figure 2.12 as an illustration. The decomposition exercise is applied using implied interest rate to compute real interest rate contribution, while contributions of RSD/EUR and RSD/USD are separated.

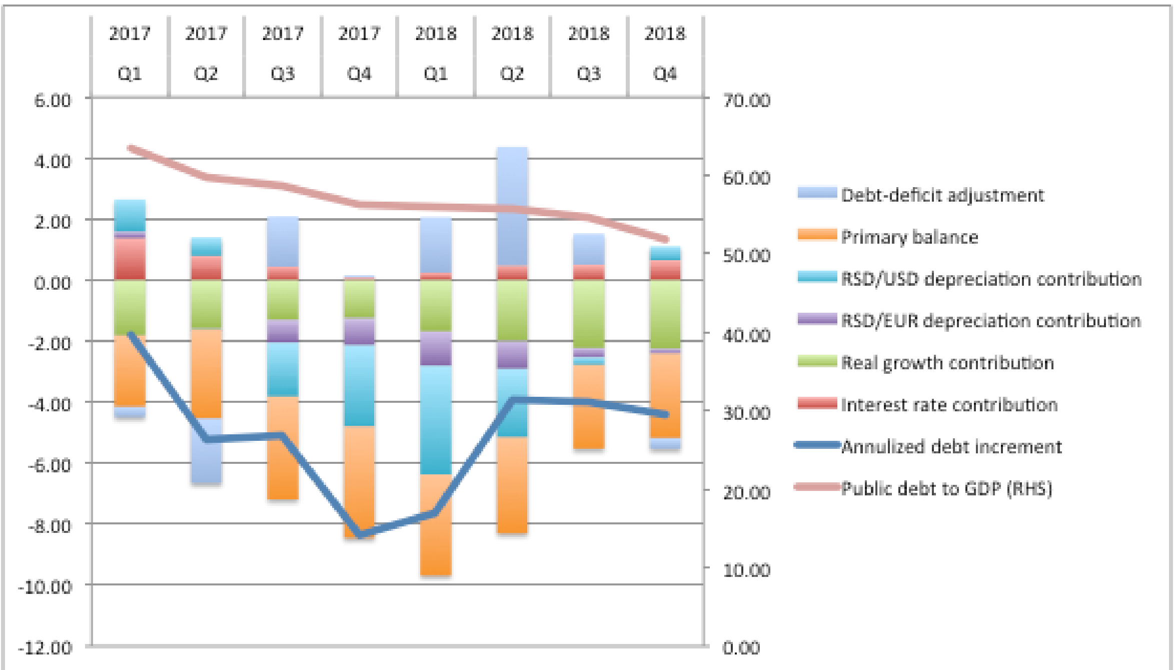


Figure 2.12: Decomposition of Serbian public debt (Maastricht definition) to fiscal and automatic (non-fiscal) contributions

Source: *own calculation*

This Figure basically illustrates how the debt increments over time can be presented as a sum of individual contributions of fiscal and non-fiscal determinants. As expected, real interest rate contribution lifted debt, while real growth contribution reduced it. On the other hand, strong debt-reducing contributions of primary balance over whole period and

RSD/USD for several quarters is a result of specific economic circumstances, which reflects successful fiscal consolidation and RSD appreciation stemming from improved balance of payment.

A logic of historical decomposition of public debt to fiscal and non-fiscal contributors can be utilized for the forward-looking debt sensitivity analysis. Within the framework of isolated shocks conjecture, all debt determinants are assumed to be independent from each other and lagged debt as well. Following the relative DAE in (2.38) and debt decomposition approach of the IMF DSA, sensitivity of public debt to isolated shock in non-fiscal determinant x can be also decomposed to a sum of partial derivatives of the particular contributions:

$$\frac{\partial \Delta d_t}{\partial x_t} = \frac{\partial RIRC_t}{\partial x_t} + \frac{\partial ERDC_t}{\partial x_t} + \frac{\partial RGC_t}{\partial x_t} + \frac{\partial pb_t}{\partial x_t} + \frac{\partial dd_t}{\partial x_t} \qquad (2.61)$$

Since a primary balance, debt-deficit adjustments and $\mathrm{RGC_t}$ are not functions of interest rate, shock in nominal interest will affect only real interest and exchange rate depreciation contributions as reads

$$\frac{\partial \Delta d_t}{\partial x_t} = \frac{1+\Delta \mathrm{fx_t}\omega_{\mathrm{t-1}}}{(1+\mathrm{rg_t})(1+\pi_\mathrm{t})}\mathrm{d_{t-1}} \qquad (2.62)$$

In case of interest rate shock, only contribution of real exchange rate depreciation will be affected:

$$\frac{\partial \Delta d_t}{\partial \Delta fx_t} = \frac{\omega_{t-1}(1+i_t)}{(1+rg_t)(1+\pi_t)} d_{t-1} \qquad (2.63)$$

Being a denominator of the DAE in relative terms, real growth shock affects each component of the decomposed debt increment, even primary balance and debt-deficit adjustment since $pb_t + dd_t = [PB_t + DD_t]/[Y_{t-1}(1+rg_t)(1+\pi_t)]$. When overall effect of change in real growth is taken into account, change in debt increment reads as

$$\frac{\partial \Delta d_t}{\partial \Delta rg_t} = -\left[\frac{(1+\pi_t)^2 + i_t - \pi_t + \Delta fx_t \omega_{t-1}(1+i_t)}{(1+rg_t)^2}\right] d_{t-1} - \frac{[PB_t + DD_t] rg_t}{Y_{t-1}(1+rg_t)^2(1+\pi_t)} \qquad (2.64)$$

Set of equations (2.61) – (2.64) explains how debt sensitivity to shocks in public debt determinants is quantified. Once when shocks are calibrated, public debt dynamics can be easily projected assuming isolated impact of the shocks.

2.5 Public debt portfolio risk indicators

The previous section illustrates that debt sensitivity analysis is not an easy task, even in case when the most simplistic approach of arbitrary calibration and isolated impact of shocks is applied. From the standpoint of DMO, the main issue with debt sensitivity analysis is that it requires development of forward-looking macroeconomic scenarios and mechanics of shock transmissions that goes beyond a scope of DMO usual business. Therefore, for the purpose of short run debt management, DMO in practice use simple risk indicators which computations are completely based on debt portfolio data. In that context, interest rate and refinancing risk are main points of interest, since those risks have high impact on debt sustainability and public finance liquidity, especially in developed countries wherein amortizing loans at fixed rates and debt in foreign currency makes small fraction of public debt portfolio. In this section I present a set of simple risk indicators that provide preliminary insight in public debt portfolio exposure to interest and refinancing risks[15], which are frequently found in DMO reports from various countries. With support of adequate information system, these indicators can computed on a regular basis using only data on public debt portfolio.

2.5.1 Interest rate risk

Financial literature on interest rate risk indicators is usually considered with risk exposure of investors to changes in market interest rates. I also follow this approach for simplicity in explanation, but in case of public debt management the government is actually issuer of the debt securities and thus stands at the opposite side of cash flows streams.

From the standpoint of debt issuer, it is hard to clearly separate interest rate and refinancing risk tracking. For both domestic and foreign currency debt, changes in interest rates affect debt servicing costs of existing debt at floating rates on reset dates, as well as refinanced debt by new issuance. Financial literature usually considers duration (Macaulay and modified) and Average Time to Re-fixing (ATR) as interest risk rate indicators, while Average Time to Maturity (ATM) is considered as refinancing risk indicator. However, these three indicators actually have the same computational background as they present weighted times of debt instruments' cash flow payments that could be described by the following formula:

[15] This section summarizes author' expertise on risk management practices stemming from the part-time work at the Serbian Public Debt Administration over the period of 10 years.

$$Duration/ATR/ATM = \frac{\sum_{t=1}^{T} t\omega_t}{\sum_{t=1}^{T} \omega_t} \quad (2.65)$$

The different choice of weighting methods allows to gradual switching of focus from interest rate to refinancing risk tracking. This issue will be further explained in more details.

Duration

The Macaulay duration (henceforth duration) is the most widely used interest rate risk indicator in portfolio debt management. The term duration has a special meaning in the context of bonds: it is a measurement of how long it takes for the investor to repay price of a bond by its internal cash flows. Duration can be viewed as a weighted average time to maturity of a financial instrument as well as for the whole portfolio, including both payments of interest and principal, where the weights are the present value of the cash flows. Mathematical expression for duration of single debt instrument is given by following equation:

$$D = \frac{\sum_{t=1}^{Tk}(t/k)\frac{DSC_t}{(1+ytm/k)^t}}{\sum_{t=1}^{Tk}\frac{DSC_t}{(1+ytm/k)^t}} = \frac{\sum_{t=1}^{Tk}(t/k)PV_t}{Bond\ price} \quad (2.66)$$

where T is maturity in years, k is frequency of coupon payments ytm is yield to maturity (YTM) which is internal rate of return that equals discounted cash flows over the bond maturity and its market price, DSC_t is debt servicing cost at time t (coupon payments at first $T-1$ periods and coupon plus principal at period T).

In the context of interest risk framework duration is usually included throughout the concept of so-called Hicks sensibility (henceforth sensibility). Intuitively, concept of sensibility can be explained in the following way: the yield to maturity of the bond, as the measure of the rate of return, consists in nominal market risk-free interest rate enhanced by set of risk premia (that was discussed in subsection 2.3.2); thus, any swing in market interest rates will change the yield to maturity and in addition market value of bond. This mechanism could be roughly mathematically expressed as:

$$P_1 \approx P_0 - \Delta i D_m P_0 \quad (2.67)$$

where D_m is modified duration (MD):

$$D_m = \frac{D}{1+ytm/k} \tag{2.68}$$

It is obvious that, *ceteris paribus*, a higher (modified) duration leads immediately to larger swing in bond prices when the interest rates are swinging from the standpoint of investor. Nevertheless, interpretation of duration from the standpoint of debtor is not so straightforward as in case of investors, having in mind that change of the interest rate does not affect nominal amounts of cash flows to be paid by debtor (if only typical fixed coupon bonds are issued). Thus, in this context duration is only sensible to use in the broader framework accompanied with refinancing risk analysis.

Therefore, previous discussion on duration and sensitivity implies following conclusions:

- Duration indicates the time length in which changes in market interest rates will not affect the nominal payment obligations; the closer duration to zero is, the smaller the period for interest re-fixing is and in turn exposure to risk of increase in interest rate. From the standpoint of government as a debt issuer, debt instruments with higher duration carry less risk than bond with lower duration.
- Debt instruments with higher duration are more sensitive to change in interest rate. Sensitivity analysis shows that the higher (modified) duration is, the higher loss in the sense of opportunity cost is realized for the debt issuer when interest rates decrease.

Although duration has very straightforward calculation in the single market debt instrument' analytical framework, it suffers from the several serious computational shortcomings when it is applied to complex portfolios like government debt portfolio, apart from some more general conceptual shortcomings (like missing to capture non-linear relationship between interest rates and prices):

- Portfolio of government debt of emerging countries usually comprises numerous non-market debt instruments (loans at fixed rates). Though in theoretical sense non-market debt instruments also decrease in value when interest rates increase, duration could not be directly computed, as the market price of debt is not known. Thus, duration could not be calculated without some additional assumption on either market price or YTM, which diminishes analytical value of duration indicator and makes interpretation ambiguous.
- Theoretically, duration of portfolio could be calculated as the weighted average of single durations, where weights are share of each security' market value to the total market value of portfolio. Nonetheless, the main computational problem for the

duration of portfolio in practice comes from the fact that each security has its own yield to maturity opposite to the concept of modified duration, which takes into account just a single yield for the sensitivity analysis. In addition, using numerous YTM for the cash flows discounting makes calculation of durations computationally very extensive.

- Government debt securities in financial markets that lack a depth are usually not traded on regular basis at secondary market. Consequently, it is not always possible to pick market prices for all issued securities at particular date (if some of them are not traded), as it is required to calculate duration.

In order to overcome these problems, international organizations usually recommend to arbitrary select some YTM and to use it as a single discount rate with respect to the currency of debt instrument indexation. For example, in analysis of Serbian public debt, World Bank used to apply 4% discount rate for USD and EUR loans and 12% for RSD loans, while in case of market debt instruments sum outstanding debt payments is considered as approximation of market value of debt instrument.

Weighted Average Interest Rate

Weighted average interest rate on government debt provides an information on average cost of public debt and it is useful indicator for the purpose of international comparisons. Basically, it is computed by following formula:

$$WAIR = \sum_{j=1}^{N} \omega_j i_j \tag{2.69}$$

where i_j is interest rate of particular debt instrument i (or YTM in case of market debt instrument), while weights are given by particular instrument principal value over the total value of all principals in debt portfolio.

$$\omega_j = \frac{F_j}{\sum_{j=1}^{N} F_j} \tag{2.70}$$

However, in practice such calculation of WAIR requires YTM for market instruments, which are usually unknown or unreliable at other dates apart from auction date at emerging financial markets.

Average Time to Re-fixing

The Average Time to Re-fixing (ATR) gives information on the exposure of the debt portfolio to changes in interest rates. High ATR will indicate low risk, because this will imply that a relatively low share of the debt will have its interest rates re-fix (or reset) in a short period of time.

Opposite to the duration, ATR doesn't take into consideration neither interest of coupon payments nor discounted values of cash flows for the calculation, just the value of principal payment. As ATR does not require information on YTM, it could be applied to the whole debt portfolio. ATR is calculated by the following formula:

$$ATR = \frac{\sum_{t=1}^{T} tF_t}{\sum_{t=1}^{T} F_t} \tag{2.71}$$

where *t* is a time of interest payment first reset (in regard to the instrument that payment is related to) and F_t is principal value of the debt instrument which interest payment is re-set at the time *t*.

2.5.2 Refinancing (rollover) risk

Refinancing risk is a risk that debt will have to be rolled over at an unusually high cost or, in extreme cases, cannot be rolled over at all. For countries that have unimpeded access to capital markets refinancing risk is a risk that government need to pay higher interest rates at a moment of next loan issue. For countries with difficult access to capital markets this notion primarily relates to the likelihood that public debt may be difficult or even impossible to refinance because of too high costs or too short maturities of the loans available.

Generally, as the level of accumulated government debt over time increases, probability that government could not be able to pay it rises and consequently investors require higher risk premium for new debt issues. However, as there is no straightforward relationship between level of debt and required risk premium, it is very complicated to execute analysis similar to Hicks sensitivity, i.e. to compute change in cost of borrowing with respect to change in debt level without engaging complex econometrical models. Thus, in practice Debt Management Offices usually use set of indicators which provide more qualitative insight in possible issues with debt rollover. Classical refinancing risk indicators in debt management comprise Average Time to Maturity, redemption profile and residual maturity.

Average Time to Maturity

Average Time to Maturity (ATM), gives information on the length of the debt's life, i.e. average residual maturity. It is the simple for calculation, as it takes into account only time to maturity and principles of each debt instrument. ATM for the portfolio is calculated according to the same mathematical formula as for the ATR,

$$ATM = \frac{\sum_{t=1}^{T} tF_t}{\sum_{t=1}^{T} F_t} \quad (2.72)$$

where t is a time of residual maturity of debt instrument while F_t is principal value of the debt instrument which matures at the time t.

It is obvious that although ATM is just natural extension of duration and ATR. However, it is usually considered in financial literature as refinancing or rollover risk indicator as because it takes into account in full the residual maturity of floating rate debt.

Redemption profile

The redemption profile is graphical indicator which shows distribution of the payment of debt portfolio across the time. Idea that lies behind is very simple: wherever large amounts of debt to be paid are concentrated at certain point in time, government face possible issues with debt refinancing and increase in cost of new dent issue. Basic calculation of redemption profile could be extended to the sub-portfolio levels, i.e. it can show also redemption profile structure in regard to currency or interest rate structure.

3 THEORETICAL AND METHODOLOGICAL FRAMEWORK OF FISCAL SUSTAINABILITY ANALYSIS

A term “fiscal sustainability” is colloquially used to describe a situation wherein the public finances appear to be in a condition which does not indicate, *ceteris paribus*, concerns about keeping fiscal and macroeconomic stability over a longer period of time. While intuition behind notion of the fiscal sustainability is clear, analysis of the fiscal sustainability requires more rigorous conceptual definition and subsequent operationalization of the methodology. Table 3.1 summarized several definitions of the fiscal sustainability from the existing literature:

Table 3.1: Summary of fiscal sustainability definitions

Source and publication	**Definition**
European Commission (2019) European Semester Thematic Factsheet: Sustainability Of Public Finances	The sustainability of public finances, also referred to as fiscal sustainability, is the ability of a government to sustain its current spending, tax and other-related policies in the long run without threatening its solvency or defaulting on some of its liabilities or promised expenditures.
European Commission (2018) Fiscal Sustainability Report 2018	Generally speaking, fiscal (or debt) sustainability is broadly understood as the ability of a government to service its debt at any point in time
IMF (2014) Fiscal and Debt Sustainability	The government is able to achieve a fiscal stance that allows it to service public debt in the short, medium and long run • without debt default or renegotiation: • without the need to undertake policy adjustments that are implausible from an economic or political standpoint; • given financing costs and conditions it faces.
IMF (2011) Modernizing the Framework for Fiscal Policy and Public Debt Sustainability Analysis.	The fiscal policy stance can be regarded as unsustainable if, in the absence of adjustment, sooner or later the government would not be able to service its debt
Adams et al. (2010) Fiscal Sustainability in Developing Asia	Fiscal sustainability is the state wherein the government budget can be smoothly financed without generating explosive increases in pubic debt (or money supply) over time.
Akyüz (2007) Debt Sustainability in Emerging Markets: A Critical Appraisal	The concept of fiscal sustainability draws on the idea that public debt cannot keep on growing relative to national income because this would require governments to constantly increase taxes and reduce spending on goods and services.

As reads in the table, conceptual definitions proposed by the intergovernmental organizations or academic literature put a sustainability focus to ability of government to service its debt/liabilities without major correction of the fiscal policy stance. In more strict sense, concept of public debt sustainability can be considered as the first step in operationalization of the fiscal sustainability concept: short-, mid- and long-term public debt sustainability is perceived as a necessary and sufficient condition to claim fiscal sustainability, too. Hence, terms “public debt sustainability” and “fiscal sustainability” are often used interchangeably, as I do in this work.

In the section on debt sensitivity analysis, it was discussed that “perfect” methodological approach to debt sustainability assessment should reflect not only possible development of the debt dynamics over time, but also risks associated with different scenarios and shocks occurrence. Also, operationalization of the methodology for debt sustainability assessment is conditional on the purpose: while macroeconomic and fiscal authorities are more interested in assessing level of debt dynamics with an objective to actively manage fiscal policy, DMO is more interested in assessing debt servicing costs over time with an objective to optimize cost-risk trade-off. This two analytical flows are schematically presented in Figure 3.1.

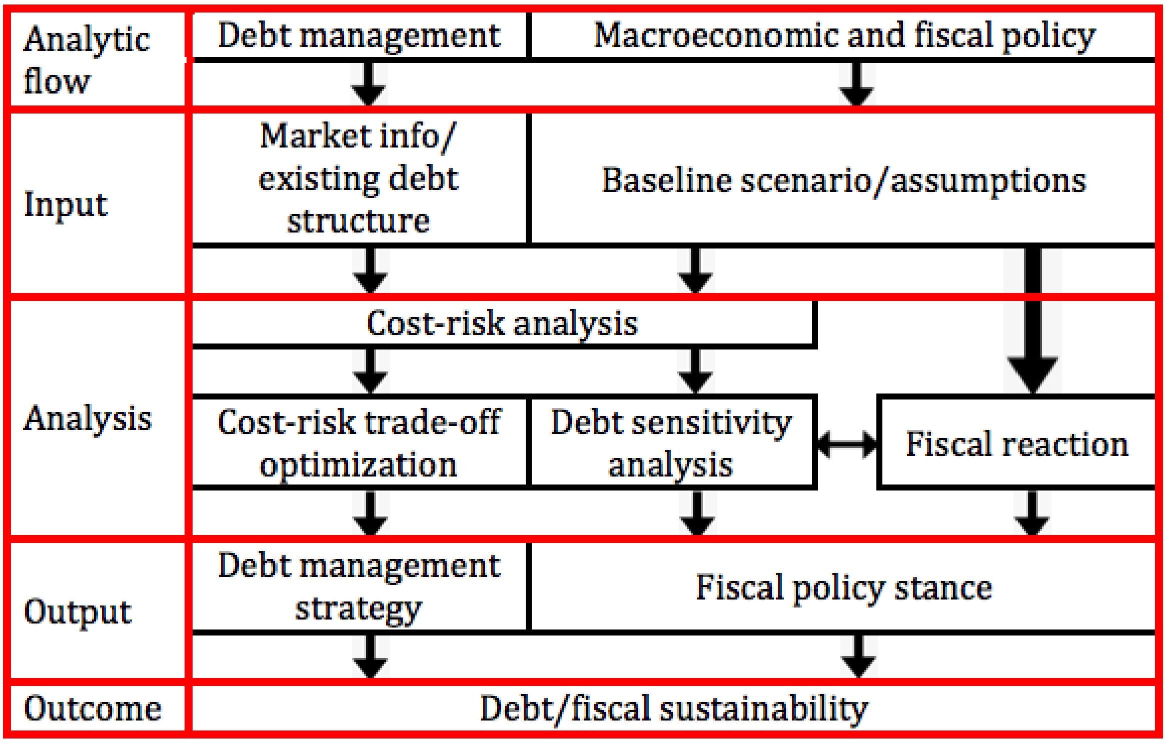


Figure 3.1: Scheme of analytical flows in fiscal sustainability assessment
Source: *author*

The previous scheme illustrates how public debt analytical framework is used in practice to generate policy decisions that in the long run will preserve debt sustainability. The government institutions in charge for macroeconomic and fiscal policy produces the baseline macroeconomic scenario with associated assumptions, that is aligned with medium-term fiscal framework, national budget and other mid- and long- term strategic documents on economic and fiscal policies. On the other side, DMO provides relevant input information on existing debt structure (type of instruments, currency, interest and term structure) and information on yields and rates on the level of individual instruments. These two types of inputs are combined to perform cost-risk analysis of public debt. Cost-risk analysis provides the most generic public debt analytical framework, as debt sensitivity analysis can be thought of as a special case of cost-risk analysis. Debt sensitivity analysis is combined with fiscal reaction analytics to produce optimal decision on the fiscal policy stance. In similar manner, DMO uses cost-risk analysis for cost-risk trade-off optimization, to produce debt management strategy that meets main objective of the public debt management defined as "*ensure that the government's financing needs and its payment obligations are met at the lowest possible cost over the medium to long run, consistent with a prudent degree of risk.*"[16] Eventually, envisaged long-term outcome of the both analytical outputs is debt/fiscal sustainability, such as defined in the Table 3.1.

Since the focus of this work is on the fiscal side of the debt management process, this chapter is organized in three sections following right-hand side of the Figure 3.1. First section presents the basic principles of the public debt cost-risk modeling. Second section deals with particular issues of debt sustainability assessment. Third section discusses fiscal reaction function as an important segment of the fiscal policy making.

3.1 Cost-Risk modeling

A risk-based approach to public debt sustainability assessment originates from an idea that risk management tools, widely used in managing business and financial risks of the business entities, can be applied on the level of national economy in managing government debt to ensure fiscal solvency and macroeconomic stability. In the most generic sense, the risk management is considered as a process of identifying, assessing and controlling threats to an entity's activities. A risk as the term refers to a corollary of uncertainty that consists of two components:

- the risk likelihood that specific outcome will occur;
- the risk exposure of the specific activity to the impact of this outcome.

In order to control risk associated with some activity, it needs to be properly measured. According to the Holton (2009), in the context of risk management there is distinction

[16] https://www.imf.org/external/pubs/ft/pdm/eng/guide/pdf/appendix.pdf

between a risk metrics - the attribute of risk being measured, and a risk measure being the operation that quantifies the risk attribute. For example, risk metrics may be volatility of portfolio debt servicing costs, and standard deviation is a measure of volatility. The risk measures can be separated to those quantifying only risk likelihood, only risk exposure or those combining both likelihood and exposure (Holton, 2009). Volatility, e.g. is a measure of likelihood that some outcome will occur, while Value-at-Risk is a measure that combines volatility with risk exposure, counting the maximum possible loss for given probability.

According to Wheeler (2004), risk management lies at the heart of public debt management and makes crucial link between the formulation and implementation of debt management strategies. Risk management is important to both sides of public debt management process, for the formulation of the debt management strategy but also for the strategy implementation on the operational level. On the strategic side of debt management and fiscal policy, policy planners and external auditors typically apply complex macroeconomic models and risk management methodologies to measure mid- to long-term risks associated to public debt attributes. While particular choices of underlying model' specification differs across countries and institutions, methodology of public debt risk assessment basically combines some form of forward-looking risk management tools and theoretical concept that describes evolution of the debt cost/level in order to transform macroeconomic inputs to risk measures output. The architecture of public debt cost-risk modeling is illustrated in Figure 3.2.

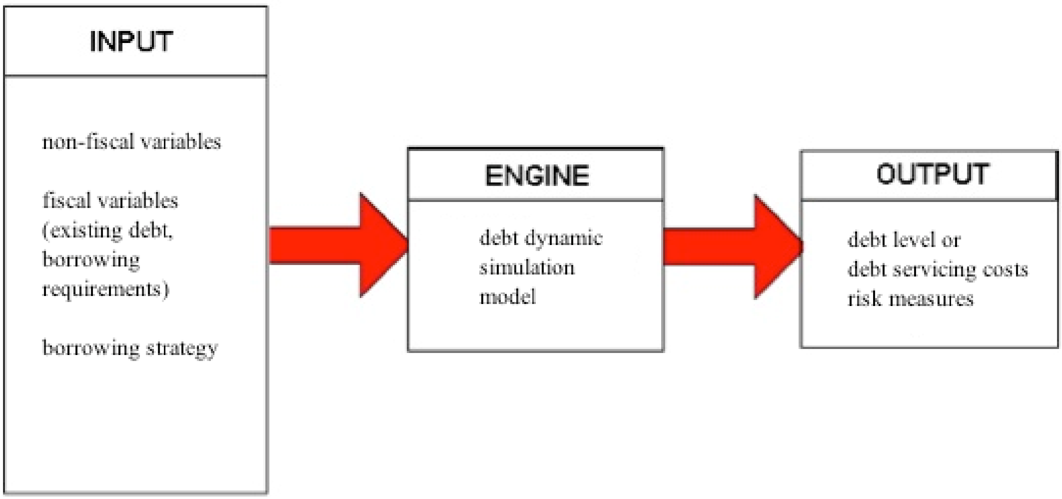


Figure 3.2: Cost-risk modeling architecture
Source: *author*

The aim of such methodology is to provide the following output:

- Estimation of cost/level of debt for the specified period when model inputs are the most expected outcomes of macroeconomic variables (baseline scenario). It gives the path of the cost or share of debt in GDP, assuming that no external shocks or shifts in macroeconomic environment will occur in the observed period;
- Estimation of cost/level of debt under the different assumptions on key variables changes (risky scenarios). Risky scenarios allow estimation of path of cost/debt assuming either different macroeconomic polices/financing strategies or external shocks occurrences;
- Estimation of debt cost/level risk exposure throughout a comparison between baseline and alternative outcomes, or/and estimation of likelihood of alternative outcomes.

Therefore, cost-risk analysis represents basic framework for estimation of change in debt servicing cost associated with change of main risk factors driving its level. Debt sensitivity analysis can be thought of as a special case of cost-risk analysis. As discussed in the previous chapter, debt sensitivity analysis estimate debt dynamics under some alternative and/or risky scenario. If some risk estimation procedure is included in analysis to depict risky scenario occurrence, than the output of debt sensitivity analysis will consist of both forecasted debt servicing costs and associated risk measurement, as illustrated in the Figure 3.3.

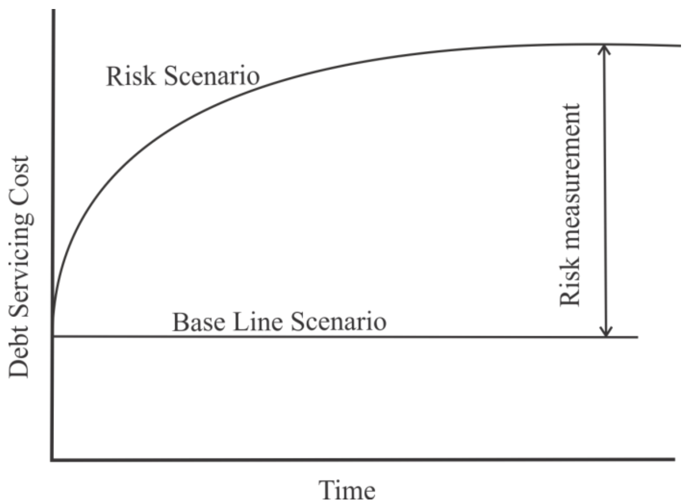


Figure 3.3: Cost-risk framework of scenario analysis
Source: *Velandia-Rubiano (2002)*

This cost-risk analysis is generally derived from risk management practice of institutional investors dealing with large portfolios of securities. It is closely related to the Markowitz theory of portfolio optimization and Value-at-Risk (VaR) evaluation, two concepts that exploits trade-off between risk and return (or cost) for the purpose of risk management. Although these two concepts are primarily developed for the purpose of investment management, they can be easily modified for the benefit of securities' issuer. Basically, portfolio optimization is a procedure that aim to minimize risk of portfolio return (objective function) subjected to given targeted value of portfolio expected return as a constraint, or the other way around – by maximizing expected return for chosen level of riskiness. Optimization is achieved throughout proper choice of portfolio weights across individual securities. Similar approach can be applied to government portfolio of debt instruments, with expected debt servicing cost as a constraint and minimization of its riskiness as an objective function.

Basic idea of VaR is to estimate level of loss in portfolio value that will not be exceeded at a given level of confidence and for a given time span. From the standpoint of debt instrument issuer, VaR can be mirrored to Cost-at-Risk (CaR) modeling, where CaR represents debt servicing cost that will not be exceeded at a given confidence level and time span. Optimal weights of portfolio and CaR value can be obtained either by analytical closed-form or numerical solution, depending on how debt servicing costs and risk are modeled in particular cases.

While portfolio optimization has some theoretical advantages over Cost-at-Risk modeling, CaR approach is by far quite more present in the risk management practice of debt management offices, due to its lower computing requirements and easiness of implementation. Cost-at-Risk may be defined in absolute or in relative terms. Absolute value of CaR counts change in value of debt servicing cost for the given time period, relative to the initial value at the beginning of the period. Relative CaR counts change in value of debt servicing costs under some risky scenario, relative to expected debt servicing cost under the baseline scenario of expected dynamic of risk factors. In that context, cost-risk framework in Figure 3.3 may be interpreted as an illustration of a relative CaR.

3.2 Debt sustainability modeling

As emphasized by Chalk & Hemming (2000), most of the analytical discussions on debt sustainability revolve around a representative agent model in which the government satisfies two types of constraints in order to preserve fiscal solvency: static budget constraint in each period and intertemporal budget constraint in the long-term horizon. While intertemporal budget constraint approach provides an important theoretical background of the fiscal sustainability concept, its empirical application is possible only to certain extent. In this section I provide theoretical framework of the fiscal sustainability concept which utilizes intertemporal budget constraint.

Within the fiscal sustainability theoretical framework, intertemporal budget constraint can be derived from the static budget constraint. Static budget constraint in the context of the debt accumulation equation corresponds to the DAE formulation given in (2.8), that value of current debt equals sum primary balance, current interest payment and debt from the previous period. A derivation of the intertemporal budget constraint presented in this work follows debt accumulation in relative terms, based on Giammarioli et al. (2007), but it can be derived also in absolute terms. If equation (2.8) is rewritten in relative terms as

$$\frac{D_t}{Y_t} = \frac{-PB_t}{Y_t} + \frac{(1+i_t)D_{t-1}}{(1+g_t)Y_{t-1}} \tag{3.1}$$

public debt dynamics can be considered as a sum of current fiscal stance $\frac{-PB_t}{Y_t}$ and inheritance of past fiscal policies $\frac{(1+i_t)D_{t-1}}{(1+g_t)Y_{t-1}}$. From the equation (3.1) follows that stabilization of the $\frac{D_t}{Y_t}$ over time in case when interest rate i_t is higher than GDP growth rate is possible only if primary balance is proportionally in surplus. However, static budget constraint is an accounting identity and does not impose any restriction on fiscal stance until lenders are willing to finance primary deficits. Nevertheless, if the government keeps running fiscal deficit for the prolonged period of time, additional borrowing will only be possible if lenders are confident that government finances will remain sound and solvent in the long run. Therefore, intertemporal budget constraint provides the answer on the question what restrictions on current and future fiscal policies should be satisfied to maintain long-term debt sustainability. The starting point in derivation is rearrangement of (3.1) by moving lagged debt to the left-hand side of the equation:

$$\frac{D_{t-1}}{Y_{t-1}} = \frac{(1+g_t)}{(1+i_t)}\left(\frac{PB_t}{Y_t} + \frac{D_t}{Y_t}\right). \tag{3.2}$$

From the (3.2) follows that at any point in time value of debt-to-GDP can be expressed recursively as a function of one-period ahead primary balance and debt, $\frac{D_t}{Y_t} = \frac{(1+g_{t+1})}{(1+i_{t+1})}\left(\frac{PB_{t+1}}{Y_{t+1}} + \frac{D_{t+1}}{Y_{t+1}}\right)$. Lets assume that debt sustainability is examined over certain future period of time $[1, \ldots, T-1]$. In such case, initial value of the debt-to-GDP can be recursively written as

$$\frac{D_0}{Y_0} = \frac{(1+g_1)}{(1+i_1)}\frac{PB_1}{Y_1} + \frac{(1+g_1)\ldots}{(1+i_1)\ldots}\frac{(1+g_T)PB_T}{(1+i_T)Y_T} + \frac{(1+g_1)\ldots}{(1+i_1)\ldots}\frac{(1+g_T)D_T}{(1+i_T)Y_T}, \tag{3.3}$$

where D_T referes to the terminal value of debt. The intuition behind this equation is that current value of debt in equilibrium long run case equals sum of discounted primary balances in each period and sum of discounted terminal value of debt, where $\frac{(1+g_1)\ldots(1+g_T)}{(1+i_1)\ldots(1+i_T)}$ is respective discount factor for the period *t*. If for a sake of simplicity discount factor is denoted as ρ_t and written in recursive manner as

$$\rho_t = \frac{(1+g_1)}{(1+i_1)}\rho_{t-1}, \rho_0 = 1 \tag{3.4}$$

then the equation (3.3) can be simplified to expression

$$\frac{D_0}{Y_0} - \rho_T \frac{D_T}{Y_T} = \sum_{t=1}^{T} \rho_t \frac{PB_t}{Y_t}. \tag{3.5}$$

The left-hand side of this equation can be interpreted as the net present value of the debt. The net present value of the public debt will be either positive if the sum of discounted primary surpluses exceeds a sum of discounted primary deficits or negative in opposite case. Yet, the equation (3.5) still does not impose debt sustainability condition since the lenders can be confident about government ability to service debt beyond the time period $[1, \ldots, T-1]$. Therefore, in the next step limited long-run horizon of the analysis is extended up to infinity, as given in the equation bellow

$$\frac{D_0}{Y_0} - \lim_{T\to\infty} \rho_T \frac{D_T}{Y_T} = \sum_{t=1}^{\infty} \rho_t \frac{PB_t}{Y_t}. \tag{3.6}$$

In the similar manner, intertemporal budget constraint in absolute terms reads as (Chalk and Hemming, 2000):

$$D_0 - \lim_{T\to\infty} \mathrm{R}_T D_T = \sum_{t=1}^{\infty} \mathrm{R}_t \, PB_t, \tag{3.7}$$

where R_T is discount factor $\mathrm{R}_T = \frac{1}{(1+i_1)}\mathrm{R}_{t-1}$. Both equations (3.6) and (3.7) tell that the intertemporal budget constraint can be satisfied even in case that discounted value of terminal debt is positive if government runs primary deficits forever by rolling its debt over and borrowing to finance its deficits. However, running primary deficits forever is basically a Ponzi scheme and such outcome is not feasible in case of the finite number of agents, as shown by O'Connel & Zeldes (1988): if some debtor holds government debt forever, she will have lower consumption in at least one period and consequently lower welfare when compared to a situation wherein she does not hold debt at all. Since rational agents are not willing to keep government debt forever if the government is running a Ponzi scheme, a no-Ponzi restriction $\lim_{T\to\infty} \rho_T \frac{D_T}{Y_T} \leq 0$ (or $\lim_{T\to\infty} \mathrm{R}_T D_T \leq 0$ in case of absolute debt) is regarded as a necessary condition to maintain fiscal sustainability. If a no-Ponzi restriction is taken into consideration, fiscal sustainability can be operationalized in relative terms as

$$\frac{D_0}{Y_0} \leq \sum_{t=1}^{\infty} \rho_t \frac{PB_t}{Y_t}, \tag{3.8}$$

or in absolute terms as

$$D_0 \leq \sum_{t=1}^{\infty} \mathrm{R}_t \, PB_t. \tag{3.9}$$

The fiscal sustainability condition imposes that fiscal policy has to respect present value budget constraint, i.e. that fiscal policy is sustainable if the present value of the primary balances (to GDP) is greater than or equal to the current level of public debt (to GDP).

Representation of the fiscal sustainability condition based on intertemporal budget constraint provides an important theoretical background for the debt sustainability assessment, but also has several limitations (Jha, 2012): it is difficult to apply, government does not have sufficient control over the future revenues, and historical data has limited usability for long-term predictions. These limitations further impose difficulties in practical application of conditions in (3.8) and (3.9) for several reasons:

- Since the sustainability conditions hold for an infinite time, one can always argue that any short- to mid-term problems with large deficits can be offset by sufficiently large primary surpluses in the future, and vice versa.
- The sustainability conditions do not impose any constraints on the structure and relationship between public revenues and expenditures.
- If fore some reason lenders are reluctant to buy debt in the short to mid run, government may experience serious illiquidity or insolvency issues even if long-term fiscal sustainability condition is satisfied. Such example was the Mexican sovereign default in 1995, although Mexico's debt in 1993 was quite low at 30% of GDP (Jha, 2012).

In regard to the difficulties for the practical application of the public debt sustainability condition, numerous empirical-based methodologies with greater focus on the mid-term sustainability (like the abovementioned IMF DSA), have been proposed in the literature. They will be discussed in the literature review section.

3.3 Fiscal reaction function

The discussion on fiscal reaction function is basically discussion on relationship between fiscal sustainability and cyclical behavior of fiscal policy, i.e. on relationship between government debt, fiscal balance and economic output. In order to satisfy its intertemporal budget constraint, government generally has two possibilities to finance outstanding debt – first by future fiscal revenues and second trough increase in monetary base. If the government is "well-behaved" i.e. responsible in respect to long-term budget constraint, only first possibility is expected to be in place, and primary balance should be adjusted to level of government debt to preserve fiscal sustainability. Indeed, it can be shown that debt-stabilizing primary balance is fully in compliance with the intertemporal budget constraint; "*A succinct and convenient way to articulate the no-Ponzi game condition is in terms of the interest rate–growth differential*" (Jha, 2012, pp. 20). It is useful to recall that debt-stabilizing primary balance (introduced in subsection 2.3.1) is defined as $\overline{pb}_t = \frac{(i_t - g_t)}{(1+g_t)} d_{t-1}$. In the context of the intertemporal budget constraint, lets assume situation in which the government is running a fiscal deficit that is financed by the further accumulation of the future debt. If the interest rate on this debt is lower than the growth rate, $(i_t - g_t) < 0$, and if unit elasticity of government revenues with respect to GDP is assumed, then, *ceteris paribus*, growth rate of public revenues will be higher than the rate of debt accumulation. Consequently, the debt will stabilize in the long-run at the steady-state level that is below the current level of debt and fiscal sustainability condition will be satisfied. The opposite holds for the situation in which growth rate is higher than interest rate.

Nevertheless, it is clear that in practice government will not hold debt at targeted steady state in each period up to infinity, for several reasons. First, debt-deficit adjustments weaken the identity relation between overall fiscal balance and debt increment. Second, targeted value of debt-stabilizing primary balance is not continuous variable in reality. Indeed, decision on target value of primary balance in the period *t* is usually made by the mid-term fiscal strategy and budget, which is prepared and adopted by the end of year *t*-1 based on the forecasts of the interest rate and growth rate. Third, even if it is assumed that values of interest and growth rate are accurately forecasted, there is always a great chance that government will face some unanticipated temporary expense or that some component of the public revenues will not be collected according to the budget. Fourth even if it is assumed that government is capable to execute budget fully according to the plan, scope of the fiscal policy is more comprehensive than simply pursuing continuously stable debt, and thus decision on the targeted value of primary balance, at least in the mid run, can be driven by the fiscal policy goals other than long run fiscal sustainability maintaining.

The latter issue is closely connected with the active role of the fiscal policy in achieving broader range of macroeconomic goals than solely fiscal sustainability. Since the rise of Keynesian economics, governments all around the world use fiscal policy tools to interfere economic activity, especially to maintain stable growth and employment during the periods of economic turmoil. In such case, running primary deficits for the prolonged periods of time to stimulate economic activity will be priority objective of fiscal policy rather than keeping stable public debt.

Since the primary balance in reality will vary around debt-stabilizing value, public debt-to-GDP ratio will vary, too. If the government behaves in responsible manner, it is expected that primary balance will covariate in the same direction as one-period lagged debt; the higher debt in the period t-1 should impose the stronger response of the government in terms of generated current primary surplus. Therefore, the government is regarded as responsible if the current primary balance reacts positively (in mathematical sense) to the debt accumulated in the past.

On the other side, active role of fiscal policy in maintaining economic activity imposes counter-cyclical reaction of the fiscal policy stance. The counter-cyclical response of the fiscal policy stance implies that government should generate primary deficits when economic activity is below potential, or generate fiscal surpluses when activity is above potential. Behaving both in counter-cyclical and responsible manner at certain circumstances can be conflicting objective, such as in case of a country with high government debt during the downturn in business cycle. While persuading counter-cyclical expansionary fiscal policy is arguably good decision to stimulate GDP growth, it can eventually increase government indebtedness and even seriously endanger fiscal solvency. Actually, dilemma whether the government should opt for expansive counter-cyclical response of fiscal policy stance or stabilize debt by reducing primary deficits has become reality for many indebted old EU member states since outbreak of global economic crises in late ‘00s.

Taking everything into account, fiscal policy stance can be represented as a function of the lagged debt and output gap as a measure of economic cyclicality,

$$b_t = f(d_{t-1}, og_t), \tag{3.10}$$

where b_t refers in general to fiscal balance used as a measure of fiscal policy stance. This relationship is known in the literature as the Fiscal Reaction Function (FRF). While overall fiscal balance can be also used, the previous discussion on intertemporal budget constraint, fiscal sustainability condition and fiscal reaction imposes that primary balance is more appropriate measure of primary stance. Additionally, in the subsection 2.3.1 it has been argued that cyclical-adjusted or structural value of primary balance has obvious advantages as a measure of fiscal stance relative to actual (headline) primary balance.

Fiscal reaction function can be formulated in the form of fiscal rule, analogue to representation of the monetary reaction function in form of the famous Taylor rule. If, for example, a CAPB is used as an indicator of fiscal stance, the FRF can be formulated in form of fiscal rule

$$capb_t = \beta d_t + \gamma og_t, \tag{3.11}$$

where $\beta > 0$ and $\gamma > 0$, in line with the previous theoretical discussion: positive β corresponds to the responsible reaction of fiscal stance to the dynamics of accumulated debt (with respect to intertemporal budget constraint), while positive γ corresponds to the counter-cyclical reaction to cyclical fluctuations of economic activity.

The main methodological issue in formulation of the policy response to indebtedness and cyclicality, consistent with fiscal policy rule as in (3.11), is a proper computation of the CAPB or structural primary balance as an accurate measure of fiscal policy stance. Larch & Turrini (2009) classified methodologies of calculating CAB into two approaches: direct estimation of cyclically-adjusted revenue and expenditure based on regression models, and correction of headline balance for estimated cyclical component. The latter has been widely adopted by international organization, either in “disaggregated”[17] version (e.g. Girouard & Andre, 2005, for the OECD) or “aggregated” version (e.g. Fedelino et al., 2009, for the IMF). Some authors also refer to this approach as “conventional”, to distinguish it from more complex methodologies of balance adjustment (e.g. IMF, 2007). According to this approach (aggregated version), adjustment of government balance that distinguishes “automatic” from “discretionary” effects is based on supposed constant elasticities of revenue and expenditure to output gap fluctuations:

$$CAOB_t = R_t \left(\frac{Y_t^p}{Y_t}\right)^{\eta_R} - G_t \left(\frac{Y_t^p}{Y_t}\right)^{\eta_G}, \tag{3.12}$$

[17] With respect to the particular budgetary items

where η_R and η_G are revenue and expenditure elasticity to output gap. It can be shown that, if output gaps are small, equation (3.12) can be approximated by equation (3.13)[18], so that $caob_t$ is now obtained by subtracting the temporary component of the budget balance from the overall value ob_t (both $caob_t$ and ob_t are expressed relative to actual GDP):

$$caob_t = ob_t - (\varepsilon_R - \varepsilon_G) * og_t, \tag{3.13}$$

where ε_R and ε_G are parameters of revenue and expenditures reaction to output gap, and og_t is current output gap as a percentage of potential GDP. Of course, if differences in reaction of budget components to output gap are assumed, disaggregation of overall budget sensitivities with respect to its components may be better solution. European Commission (2005) used disaggregated sensitivity parameters calculated as $\varepsilon_j = \eta_j \frac{BI_{j,t}}{Y_t}$ to estimate cyclical effects for EU countries, where η_j is elasticity and $BI_{j,t}$ is a nominal value of given budgetary item. However, use of sensitivities in someway leads to inconsistency in $caob_t$ estimation, as subtracted temporary component is expressed in units of potential output, while overall balance is expressed in units of actual output. This was criticized by Mourre et al. (2013), who propose use of semi-elasticities instead of sensitivities, calculated as $s\eta_j = \varepsilon_j - \frac{BI_{j,t}}{Y_t}$, which corrects inconsistency in previous methodology and will be used in future estimation of EU countries cyclical effects.

Beside theoretical issues, practical problem remaining is how to calculate particular elasticities of revenue and expenditure components with respect to GDP fluctuations. Girouard & Andre (2005) proposed methodology[19] based on separate estimation of elasticities to output gap for each GDP-sensitive budgetary item: personal income tax, social security contributions, corporate income tax and indirect taxes for revenues, together with unemployment-related spending for expenditure. This approach requires demanding computation of both the elasticities of revenue and expenditure components with respect to their base, and the reaction of the different tax or expenditure bases to the output gap. Then, estimated elasticities of particular revenue' components $\eta_{G,i}$ (or $\eta_{G,U}$ for expenditure[20]) are averaged using the share of each on the total current tax burden $\frac{R_i}{R}$ (or $\frac{G_U}{G}$ for spending) as weight.

[18] For details of calculation, see Mourre et al. (2013).

[19] This methodology is developed within General Economic Analysis Division of the OECD Economics Department, so this is also often referred in literature as OECD (2005).

[20] Actually, there is no averaging of expenditure' elasticities as only unemployment-related spending G_U is sensitive to GDP.

Calculating elasticities according to Girouard & Andre (2005) requires longer time series of revenue and expenditure components for computation of steady weights and even more important, for reliable regression-based estimate of elasticities. European Commission (2005) applied this approach, based on 1995-2004 values of budgetary items, and reported empirical estimation of overall elasticities, showing that average elasticity of revenue and expenditure for EU 25 countries is very close to one and zero, respectively. Fedelino et al. (2009) use this result to propose simplified methodology for adjustment of primary balance in countries with low data availability. They suppose unit elasticity of revenue and zero elasticity of primary expenditures, which transforms equation (3.12) to:

$$CAOB_t = R_t\left(\frac{Y_t^p}{Y_t}\right) - G_t. \tag{3.14}$$

Interest spending INT_t is treated as an exogenous component of expenditure, which is a kind of a compromising solution. Clearly, it is non-discretionary component of expenditures being beyond direct control of the fiscal authorities, but also not cyclical in the same way as revenue and expenditure components are[21]. If interest spending is subtracted from government expenditure, than equation (3.14) could be rewritten as:

$$CAPB_t = R_t\left(\frac{Y_t^p}{Y_t}\right) - PG_t, \tag{3.15}$$

where $CAPB_t = CAOB_t - INT_t$ and $PG_t = G_t - INT_t$ are cyclically-adjusted primary balance and primary expenditure, respectively. The question remaining is whether balance ought to be scaled by potential or actual GDP in equations (3.14) and (3.15). Mourre et al. (2013) argue properly that use of actual GDP for scaling is not correct, as actual GDP is also strongly affected by business cycle. However, policy makers and the public do not prefer to use potential GDP in analysis and reporting, as pointed out by Fedelino et al. (2009), who discuss the issue of "*trade-off between analytical rigor and convenience of commonly used indicators*".

Previously discussed methodologies basically propose guidelines for adjustment of balance for automatic changes of its components, stemming from GDP fluctuations. Although cyclical fluctuations are reasonably considered as the largest and most persistent non-discretionary component of balance, recent empirical analyses reveals evidences that they are not the only source of temporary deviations of revenue and expenditure from their permanent values. In the most general sense, one can argue that any variable affecting the

[21] While revenue and expenditure are directly affected by cyclical fluctuations of GDP, interest spending is affected indirectly by cyclical conditions, mostly throughout the interest and exchange rate transmission channels.

government revenue or expenditure may become source of transitory deviations of balance from its discretionary value. According to Bornhorst et al. (2011), all of these factors can be classified in two categories: one-off changes in budgetary items and so-called “beyond-the-cycle” factors, whose fluctuations are likely to cause temporary deviations of revenue and expenditure from their steady values, but not perfectly correlated with business cycle.

One-off components of budgetary items are usually depicted as transitory changes in revenue or expenditure that affect government fiscal position only in year when realized (or with very limited influence in subsequent years). Gali & Perotti (2003) depict such one-off components as “non-systematic” or “exogenous” change of balance that is consequence of exogenous political processes or extraordinary non-economic circumstances. Joumard et al (2008) emphasized that appropriate assessment of fiscal stance, in addition to cyclical adjustments, should be based on an fiscal indicator that effectively eliminates impact of one-offs and maintain consistency if applied to group of countries for the purpose of comparative analysis.

Beyond-the-cycle adjustment is related to idea that balance ought to be corrected for macroeconomic fluctuations other than those of output. As mentioned, even interest spending as a component of expenditure is sensitive to macroeconomic fluctuations, however this concept is predominantly oriented toward the revenue side of balance. Roughly, we can categorize two groups of factors affecting the revenues: fluctuations of prices and fluctuations of output structure. First group considers two types of prices changes with respect to the influence on tax bases or elasticities: assets (real estate and equity) and commodity (or terms of trade) prices. Bornhorst et al. (2011) make a good point on these differences, arguing that cyclical adjustment only for output gap could miss the nature of revenue fluctuations, as economic expansion driven by asset price boom will have large effects on revenue than expansion based on commodity prices, since consumption is typically more heavily taxed than export. Indeed, empirical work confirms relevance of adjustment for price fluctuations. Turner (2006) compares cyclically adjusted balance by standard OECD method (Girouard & Andre, 2005) with balance additionally corrected for commodity prices for Australia, finding that during exceptional periods of rapid change in commodity prices these two measures can be very different. Daude et al. (2010) examines effects of commodity cycles for the group of Latin American countries and conclude that they may be as relevant as economic cycles due to significant impact on total fiscal revenues. Morris & Schukneht (2007) analyze impact of equity and real estate prices on fiscal revenues for 16 OECD countries by adjusting balances for both business and asset price cycles, and argue that asset price movements might be “missing link” that explains unexplained changes in CAB. Price & Dang (2011) develop comprehensive methodology of balance adjustment for asset prices and point out that conventionally adjusted balance ought be corrected to the extent in which asset prices fluctuations are uncorrelated to the output cycle.

Adjustment of balance for output composition impact stems from idea that aggregate output gap cannot capture effects of unbalanced growth, i.e. that components of government revenue and expenditure might be in different phases of the cycle (Bouthevillain et al. 2001). Consequently, use of steady weights for revenue and expenditure components when cyclically adjusted, as in EC (2005), may be inappropriate. Bouthevillain et al. (2001) analyze this issue for European countries and find evidences that composition effects stemming from unbalanced growth haven’t been significant for the euro area as a whole, but can be particularly important at the country level. Recent papers on this topic were mostly concerned with adjustments of indirect tax revenue for effects of absorption fluctuations, as a special case of adjustment for output composition effects (Bornhorst et al., 2011). Basically, if absorption is boosted by current account (external) imbalances, this will create increase in revenue that will be captured by cyclical fluctuations of output (internal imbalances) only to the level in which they correspond to the fluctuation of absorption. IMF (2007) analysis of Bulgarian economy reveals that fluctuations of all tax components during boom years were related to external rather than internal imbalances, and consequently new methodology for proper adjustment of balance for both absorption and output cycles is proposed (CAAB). Latter researchers, who adopted this methodology, find that CAAB and CAB can significantly differ. Lendvai et al. (2011) estimate CAAB for EU countries and compare it to conventional CAB, and show that neglecting the absorption adjustment could have mattered substantially for a proper assessment of structural fiscal positions. Dobrescu & Salman (2011) calculate CAAB for wider sample of 59 advanced and emerging countries and show that ignoring absorption cycles leads to biased estimation of fiscal stance up to 1.5 percent of GDP.

4 LITERATURE REVIEW

The subject of this work covers variety of the economic topics with exceptionally high number of related studies. Issues of the fiscal sustainability gained particular attention during the recent sovereign debt crisis, followed by proliferation of the related empirical literature. Since the full scope overview of the debt/fiscal sustainability related studies would be an immense task, literature overview provided in this chapter is predominantly dealing with the papers that are closely related to the empirical research conducted in the Chapter 6. More specifically, focus of review of the theoretical and methodological work is on the studies that generally deals with the issues of uncertainty and risks surrounding projections of public debt levels and costs. In review of empirical work, focus is additionally narrowed down to studies dealing with application of fiscal reaction function and projections of debt determinants within fiscal sustainability analysis framework.

4.1. Review of theoretical and methodological findings

Putting government debt together with temporary deviations of government balance and GDP on the explanatory side of budget deficit equation could be traced to the work of Barro (1979), on so-called tax-smoothing hypothesis. Under the certain assumptions on cost of tax collection, he hypothesized that optimal tax policy requires application of uniform tax rate to smooth revenues over time and satisfy inter-temporal constraint. Huang & Lin (1993) point out important implication of optimal taxation, that optimal tax rate is solely determined by permanent components of expenditure and aggregate output. In his later work, Barro (1986) set tax-smoothing model of deficit, with expected inflation, measure of temporary government spending, temporary shortfall of output and changes in interest rate on the explanatory side. While analyzing fiscal solvency in USA, Bohn (1998) adopted rationale of Barro's tax-smoothing model that fiscal policy decisions ought to be driven by permanent component of expenditure and output[22]. Main legacy of the Bohn's (1998) milestone work reflects in essential specification of FRF as a model-based framework of fiscal policy analysis, and interpretational claim that as long as primary deficit positively reacts to debt, government respects inter-temporal budget constraints and fiscal policy is responsible.

Consideration of tax smoothing as debt management objective became first mainstream line of reasoning about public debt governance and open the discussion on the issue of

[22] Permanent component of output as a tax basis determines permanent level of revenue.

optimal debt structure[23] that should provide a hedge against macroeconomic shocks to the government budget, that is, by choosing a portfolio of securities with returns that co-vary negatively with government consumption and positively with the tax base and, thus, output (Lucas & Stokey, 1983; Barro, 1995; Bohn, 1990; Missale, 1997). Licandro & Masoller (2000) provide analytical solution for the optimal debt structure, considering the tax smoothing as the government' debt management policy objective. Missale (2000) proposed similar approach in regard to "Stabilization and Growth Pact" introduced to European Monetary Union that has been limited budget deficit of member countries to 3%, by stating budget stabilization as debt management approach objective and set the analytical solution for the optimal debt structure.

In general, budget stabilization or tax smoothing approach provides important insights in decision making process in public debt management and emphasized importance of the correlation matrix between key macroeconomic variables like inflation, GDP growth and interest and exchange rates for the optimization of debt structure. However, tax smoothing approach as public debt management objective was criticized in terms of its practical accuracy. Alesina, Roubini & Cohen (1997) argue that debt managers ignore the budget stabilization approach because budgetary policy is not driven by tax smoothing motives. They claim that governments put up with the welfare losses caused by tax rate fluctuations. De Haan & Wolswijk (2005) attribute the lack of practical application of the budget stabilization approach to the fact that countries find it difficult to investigate how the various macroeconomic variables affect the debt costs and the balance. Furthermore, it is not known what shocks (demand or supply shocks) a country may expect. As a result, it is practically impossible to determine the right hedge for the budget balance in advance. Additional critics that could be addressed to this approach is that it says little about exposure of debt portfolio to risk and costs of debt.

New line of academic reasoning has started at the beginning of the 00's with Bergström & Holmlund (2000) work[24] which introduced new approach to debt management that set minimization of debt costs as an objective of their public debt management model. Their numerical[25] approach comprises modeling of the inflation, GDP, short and long-term

[23] The optimal debt composition is derived by looking at the relative impact of the risk and costs of the various debt instruments on the probability of missing a well-defined stabilization target, e.g. the stabilization of the debt ratio at some target value (OECD 2005, pp. 13)

[24] This working paper of Swedish Debt Management Office is usually cited as initial comprehensively developed framework for minimizations of public debt cost by majority of other relevant authors. According to Silva, Cabral & Baghdassarian (2006), Granger (1999) on behalf of Portugal Debt Agency presented related framework limited to stochastic considerations of interest rates only at World Bank Second Sovereign Debt Management Forum.

[25] The results are obtained by simulations instead of applying analytical solutions.

interest rates and exchange rates using stochastic processes in order to capture stochastic nature of risk factors and calculate costs of debt under different financing strategies.

An incentive to development of new approach was given by the International Monetary Fund (IMF) and the World Bank (WB), which "Guidelines for the Public Debt Management", issued in 2001, states that the main objective of public debt management is "*to ensure that the government's financing needs and its payment obligations are met at the lowest possible cost over the medium to long run, consistent with a prudent degree of risk*". In practical sense, it means that governments should look for such debt structure that minimize potential loss of adverse shocks and market movements by efficient management of the risks. Additionally, Guidelines clearly stated six types of the risk[26] that governments should manage.

Cost minimization approach was widely accepted by debt management authorities worldwide and included as public debt management objective in associated strategies (Wheeler, 2004). Requirements for building the cost and risk trade-off analysis framework by IMF and WB Guidelines directed researchers to further developments of appropriate risk assessment methodology, mostly based on use of Cost-at-Risk approach. Implementation of CaR methodology for risk assessment faced the difficulties, as for other probability density functions than normal, especially those with a tail of the distribution that is not exponential, the statistical indicators can not be easily evaluated in a closed form (Bernaschi, Missale & Vergni, 2009). Consequently, major development of the comprehensive methodology for risk assessment of public debt is based on numerical approach and stochastic simulations of cost and debt dynamics under the different scenarios of financing strategies in similar spirit of Bergström & Holmlund (2000) and Bergström, Holmlund & Lindberg (2002). Several pioneering examples of cost-risk stochastic simulation frameworks include:

- Bodler (2002, 2003) construct a simple reduced-form model describing the joint evolution of the economic business cycle, the government's financial position, and the term structure of interest rates. In addition, he later upgrades this methodology with explicit modeling of CaR, which was previously introduced as risk assessment tool by Danish National Bank (1998) in very similar spirit to Value-at-Risk approach;
- Hahm & Kim (2004) combine the concept of the efficient frontier from Markowitz portfolio theory with CaR penalties and provide a framework to identify and achieve a benchmark portfolio structure for government debt based upon the trade-off between expected debt service cost and risk;

[26] These are market, rollover, credit, settlement, liquidity and operational risk.

- National Bank of Denmark (2006) presented its CaR model gradually developed for several years, first for the management of the interest-rate risk on the domestic debt and later expanded to include foreign debt and the assets of the central-government debt for measuring the trade-off between costs and risks;
- Pick & Anthony (2006) made the simulation framework consists of three building blocks: a macroeconomic model of inter-related equations for modeling output gap, the primary net financing requirement, inflation and the short interest rate; yield curve models of interest rates; and the debt strategy simulation component which is used to compute the cost and risk measures for given debt strategy.
- Renne & Sagne (2008) propose similar to latter framework, with one main block comprises the vector autoregression modeling of GDP growth, inflation, short-term interest rate, and rate spread, with two additional blocks for modeling of the yield curves and dynamics of the primary fiscal balance.

Stochastic simulation modeling as an approach to public debt management have been applied in decision making process by several debt management authorities, including the National Bank of Canada (Bodler, 2002; 2003), the Swedish National Debt Office (Bergström & Holmlund, 2000; Bergström, Holmlund & Lindberg, 2002), National Bank of Denmark (2006), Brazilian National Treasury (Silva, Cabral & Baghdassarian, 2006), Dutch Treasury (2007), etc. For an overview of general algorithm of stochastic debt strategy simulation modeling in OECD countries see Risbjerg & Holmlund (2005). For more general overview of the advances in risk management practices within public debt management in OECD countries is given by OECD Public Debt Management Working Group (2005). General overview of the cross-country involvement of risk management into the national debt strategies in regard to currency, interest rate and refinancing risk is presented by Melecky (2007a).

There are several critics that could be addressed to cost minimization approach and its application to public debt management. Missale (2000) criticize this approach conceptually arguing that the objectives of minimizing the expected cost of debt servicing relative to desirable level of risk is of little help operationally. Bernaschi, Missale & Vergni (2009) point to the danger of assuming the cost-risk minimization of the interest expenditure as the main objective of debt management, which reflects in choice of sub-optimal debt strategies when minimization of the interest expenditure comprise too short horizon or does not consider that risk premiums may reflect a fair price for insurance. Additional critic could be addressed to the use of numerical approaches in the proposed frameworks, which do not provide an explicit analytical solution that would guide conceptually to the choice of optimal structure, and thus serve as a base for a more judgmental analysis (Melecky, 2007b). Also, majority of the proposed frameworks are concerned primarily with analysis of market risks, more specifically interest rate risks, while influence of the risks from the fiscal side is neglected and not included in stochastic simulations. In addition, in analysis asset side of the government balance is also usually neglected. Vlenadia (2002) propose an asset-liability management (ALM) approach to risk assessment of public debt which combine CaR and portfolio optimization with ALM approach usually used in financial institutions.

IMF Sustainability Assessment (DSA) framework for Market Access Countries[27] (MAC) was introduced in 2002 and refined in 2003 and 2005. The latter framework for low income countries[28] (LIC) was developed jointly with the World Bank in 2005. DSA framework is primarily based on debt accumulation equation and thus belongs to the financing gap approach[29] to public debt sustainability assessment (Tran-Nguyen & Tola, 2009). Essentially, it allows sensitivity analysis and stress testing of debt under different scenarios of economic policies and macroeconomic shocks.

In regard to the existing literature, both debt sustainability and cost minimization approach are mainly based on numerical approach and share the common cost and risk assessment tools (CaR measures, stochastic simulations, scenario analysis, stress testing). However, public debt sustainability approach is primarily subjected to stress testing and sensitivity analysis of public debt dynamics under the different scenarios of government economic policy or possible exogenous shocks. Thus related outcome of the debt sustainability approach is usually some indicator on debt distress, like probability of default (Garcia & Rigobon, 2004; Xu & Ghezzi, 2003; Gray, Merton & Bodie, 2007 or Gapen at al, 2008).

DSA was widely criticized, from the conceptual level (Wyplosz, 2011) to methodological level, as it is highly standardized and implemented in deterministic manner with quite unrealistic assumptions on size and probabilities of possible shocks (Debrun, Celasun & Ostry, 2006; Gray at al, 2008). Despite shortcomings of traditional DSA-based fiscal sustainability analysis which often does not take into account the effects of uncertainty, the IMF's framework for fiscal sustainability analysis is quite useful to the practicing economist (Burnside 2004). In order to include uncertainty in the fiscal sustainability analysis, several different approaches have been taken to model the interaction between economic variables in stochastic simulation studies.

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[27] See Assessing Sustainability, Information Note on Modifications to the Fund's Debt Sustainability Assessment Framework for Market-Access Countries (2002), Sustainability Assessments – Review of Application (2003) and Methodological Refinements (2005)

[28] See Operational Framework for Debt Sustainability Assessments in Low-Income Countries - Further Considerations (2005)

[29] For detailed discussion on main approaches to public debt sustainability, see Tran-Nguyen & Tola (2009)

- Barnhill & Kopits (2003) apply the VaR methodology to estimate the distribution of government net value taking into account the evolution of the whole public sector balance sheet and implicit government liabilities in regard to volatility and co-movements of key risk variables to public sector vulnerability.
- Xu & Ghezzi (2003) model the flows in the government budget as stochastic processes in order to estimate default probabilities, using a system of Brownian motions as the basis for their simulation. In addition, they map obtained default probabilities into a term structure model to compute fair pricing of the government's debt.
- Mendoza & Oviedo (2004) propose a quantitative framework for the equilibrium dynamics of public debt of a two-sector small open economy subject to random income shocks, given tax and expenditure policies. This framework emphasizes macroeconomic uncertainty and the transmission mechanism by which this uncertainty affects debt dynamics when asset markets are incomplete and public debt is a dollarized.
- Giavazzi & Missale (2004) paper connect cost minimization approach with debt sustainability as they set stabilization of the debt-to-GDP ratio as the objective function. Their setup differs than the other approaches as it provides analytical solution for the optimal weights of the components in government debt portfolio.
- Ferrucci & Penalver (2003) present a model that calculates the distribution of future paths of the debt to GDP ratio by running the forecasts on key macroeconomic variables, generated from a VAR modeling. These distributions can be used to measure the probability of certain debt outcomes and to assess debt sustainability. Garcia & Rigobon (2004) work propose the similar approach. They simulate paths of public debt under the various scenarios of possible shocks for the Brazilian economy and compute probabilities that the simulated debt to GDP ratio exceeds a given threshold deemed risky. Lewis (2004) applied their methodology to Jamaican data.

It is important to emphasize that all of these approaches are subjected and applied to the emerging market economies. Burnside (2004) gives an excellent overview of Barnhill & Kopits (2003), Xu & Ghezzi (2003) and Mendoza and Oviedo (2004) models and their application to the data of Latin America emerging economies. However, Ferruci & Penalver (2003) and Garcia & Rigobon (2004) works became the basis for the most exploited research direction as they are closely subjected to the IMF (2002, 2003) Debt Sustainability Assessment (DSA) framework.

In addition to DSA related frameworks, several different approaches that include uncertainty in the debt sustainability assessment are proposed, most notably Hostland &

Karam (2006) macroeconomic model consists of a few reduced form equations for aggregate demand/supply dynamics and the inflation process and Gray, Merton & Bodie (2007) or Gapen at al. (2008) who propose a new approach to measure, analyze, and manage sovereign risk based on the theory and practice of modern contingent claims analysis.

4.2 Review of empirical research

According to the Adams et al. (2010), three different approaches in empirical assessment of the fiscal sustainability can be identified:

- Testing the stationarity of time series
- Testing compliance with fiscal rules
- Scenario or stress testing

The time series approach tries to assess whether public indebtedness, measured in level or as a ratio to GDP, is stationary time series. If the debt dynamics has a unit root, this would indicate that debt is not sustainable (Jha). Beside public indebtedness, time series approach can be extended to assessment of stationarity of other fiscal variables such as government spending and revenues or interest payments (Trehan & Walsh, 1991; Haug, 1991). The alternative time series approach utilizes literature on asset price bubbles to test whether the time series for debt stocks include a bubble term that implies fiscal policy being unsustainable (Chalk and Hemming, 2000). Nevertheless, such simple approach to empirical assessment of fiscal sustainability in the recent years has been upgraded up to the methodology of testing of cointegration relationships that would be expected to hold among various variables if policy fiscal policy is sustainable, see, Ozkaya (2013) or Amankwah et al. (2018) as the recent example of empirical studies based on cointegration testing.

Testing compliance with fiscal rules referred to estimation of fiscal reaction and consistency of estimated coefficients with values stipulated by the fiscal rule, such as those specified in equation (3.11). Based on US data for the period 1916-1995, Bohn (1998) shows that after controlling for temporary spending (military outlays) and output fluctuations, primary balance positively responds to debt to GDP ratio and draw two important conclusions: for given period, US debt to GDP was mean-reverting process and US fiscal policy was sustainable in sense of satisfying inter-temporal constraint. This result is confirmed using even longer US data series for the period 1793-2003 (Bohn, 2005).

Since Bohn (1998) initial research, literature on estimating fiscal reaction and examining debt vis-à-vis primary balance relationship has extensively grown. IMF (2003) estimates FRF for the period 1970-2002, for large sample of emerging and industrialized economies, and finds significant positive reaction of balance to debt. Afonso (2005) provides a summary of early literature[30] focuses on examining relationship between public debt and primary balance in industrialized countries, emphasizing that all of these works confirms positive responds of primary balance to debt dynamic in favor of responsible behavior of governments. This result was also found to hold in his analysis for the sample of EU 15 countries in four different sub-periods: pre- and post-Maastricht, and pre- and post-SGP period[31]. Mendoza & Ostry (2007) examine the issue of fiscal solvency in industrial and emerging market countries using Bohn's (2005) approach, finding positive conditional response of primary fiscal balances to changes in government debt.

Beside simple interpretation of positive response of balance to debt as an indicator of responsible fiscal behavior, FRF becomes a tool of more explicit model-based framework for assessment of solvency and debt sustainability. Abiad & Ostry (2005) use the estimations of FRF in analysis of government overborrowing in emerging countries to calculate benchmark levels of sustainable debt. European Commission (2011) estimates FRF for EU 27 countries, and uses it for forecasting primary balances and derivations of debt sustainability thresholds. Celasun et al. (2006) incorporate FRF as a building block of stochastic Debt Sustainability Assessment (DSA) framework, which deterministic mode is widely used by the IMF exercises of forecasting debt to GDP ratio. Medeiros (2012) applies similar DSA methodology to assess FRF and forecast debt dynamic for selected EU member states. Ostry et al. (2011) use data for 23 advanced economies over 1970–2007 period, and find evidences on so-called "fiscal fatigue", i.e. non-linear marginal response of primary balance to lagged debt with threshold around 90-100 percent of debt to GDP.

Empirical estimations of FRF mainly confirm positive response of primary balance to government debt, regardless of countries and time span comprised by samples. However, when it comes to cyclical character of fiscal policy and response of balance to GDP fluctuations, situation is not so straightforward. Empirical findings suggest that fiscal policy and government spending are pro-cyclical in developing countries, opposite to developed countries where they are counter- or a-cyclical. Ilzetzki & Vegh (2008) provide

[30] Literature from the period 1998 – 2005.

[31] Many economists expressed concerns that Maastricht Treaty and Stability and Growth Pact (SGP) put constraints to EU countries on conducting stabilizing fiscal policy; this issue was quite often explored in other works on fiscal policy of EU members.

an overview of literature supporting this view, while results of their own analysis also confirm the pro-cyclical character of fiscal policies in developing countries.

The most frequently cited explanations of the pro-cyclical behavior in developing countries blame credit constraints binding government borrowing and weakness of political and institutional infrastructure. Credit constraint argument (Gavin & Perotti, 1997; Kaminsky et al., 2004) is popular economic explanation advocating that during good times low cost of borrowing gives incentive to the governments to borrow, while during bad times high cost ties borrowing capacities of government. Weakness of political and institutional infrastructure as a possible explanation is related to pro-cyclicality in economic upturns, including the voracity effect of Tornell & Lane (1999) and the "starve the Leviathan" argument of Alesina et al. (2008). Voracity effect claims that pro-cyclical response is motivated by struggle of groups with political power to acquire surge in wealth caused by positive GDP shocks, putting a pressure on fiscal authorities for more than proportional increase in spending. “Starve the Leviathan" argument claims that voters demand more public goods or fewer taxes to prevent corrupted governments from appropriating rents when the economy is doing well. On the other hand, some other authors like Rigobon (2004) has questioned methodological approach in studies finding differences in cyclical behavior between developing and industrialized countries, asserting it doesn’t properly deal with different shocks to which these two groups of countries are exposed.

Some of the works dealing with assessment of fiscal policy cyclicality engage FRF to estimate character of its behavior. In this strand of research, FRF is considered as a model of “fiscal rule”, i.e. cyclical relation between an indicator of fiscal policy (cyclically-adjusted balance) and an indicator of business cycle (output gap), controlled for effects of debt-stabilization motive of fiscal authorities (lagged debt). In such FRF setup, systematic positive response of balance to change in output gap indicates counter-cyclical character of fiscal policy, for example if negative output gap is widening, deficit rises (or surplus falls) meaning that government persuade expansionary fiscal policy. Some early works on this issue (Fatas & Mihov, 2002; Wyplosz 2002) regress unadjusted balances to output gap, however Gali & Perotti (2003) criticized this approach, pointing out that automatic adjustments of the primary balance and interest expenditure to the cyclical conditions could be non-negligible in size relative to discretionary value of balance. In addition, they also warn that even discretionary value of balance could be imprecise representation of systematic response of government fiscal policy to business cycle, as it often encompasses exogenous a-cyclical component, in line with Bohn’s observation on influence of war outlays while estimating FRF in USA.

Contrary to Fatas & Mihov (2002) findings that size of the counter-cyclical policy of EU countries declines in post-Maastricht period, Gali & Perotti (2003) find evidences that counter-cyclicality of EMU and industrialized countries increase over time. Hagen and Wyplosz (2008) adopted Gali & Perotti (2003) FRF specification[32] and also find evidence that fiscal policy in EMU became more counter-cyclical and more used to restore competitiveness instead of simple boosting demand. Another issue that raise attention of researchers is possibly different response during the "good" and "bad" times[33], for example Turini (2008) used FRF that regresses change of CAPB to lagged debt and output and find evidences that fiscal policy in EMU countries tends to be pro-cyclical in good times, and that this phenomenon is completely driven by expenditure dynamic.

Few existing empirical studies of fiscal policy behavior in EEC, based on FRF estimation, are almost exclusively limited to CEE 10 group of countries[34] – ten EEC that accessed EU as the new member states, and mostly concentrated on cyclical behavior of fiscal policy. Eller & Urvova (2012) estimate FRF within DSA framework, based on data of seven countries out of CEE 10 group and Croatia, and find persistent positive response of non-adjusted primary balance to both lagged debt and output gap. Zdravkovic et al. (2013) obtained very similar results for broader group of EEC. In both studies authors hypothesize that counter-cyclical response of primary balance stems from automatic stabilizers. Staehr (2007) compares cyclicality of old EU members and CEE 10 using the non-adjusted balance in FRF modeling, and find that CEE 10 fiscal response were more counter-cyclical than EU old members. In latter work, he again provides evidences on counter-cyclical response of overall balance of CEE 10, which is entirely driven by the revenue side (Staehr, 2010). Some papers attempt to analyze fiscal behavior of single EEC, for example Angelovska Bezovska et al. (2011) find that the fiscal policy behavior of FRY Macedonia was pro-cyclical prior to adoption of new monetary policy framework in 1996, but turned to counter-cyclical afterwards.

A third group of tests relies on the DSA approach by the IMF, that utilizes scenario or stress tests. As previously mentioned, stochastic modeling to DSA framework was introduced by Ferruci & Penalver (2003) and Garcia & Rigobon (2004) was followed by Debrun, Celasun & Ostry (2006), who applied stress testing to the five emerging market countries. In order to relax the assumption on passive acting of fiscal authorities to the deterioration of public debt, they extended the DSA stochastic methodology with the fiscal reaction function, estimated on panel data on 34 emerging countries. Penalver & Thwaites

[32] Opposite to FRF specifications focused on contemporaneous output gap vis-à-vis balance, "fiscal rule" FRF specification in Gali & Perotti (2003) manner use expectation of output gap from previous year instead.
[33] Good times meaning that output gap is positive and bad times that is negative.
[34] Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia.

(2005) estimate an econometric model of the determinants of public debt dynamics and use this model to simulate the effect of different fiscal policy rules for future paths of debt and to derive the set of fiscal policy rules which stabilize public debt dynamics.

Tanner & Samake (2006) assess both retrospectively and prospectively the sustainability of fiscal policy under uncertainty in three emerging market countries. Their employ similar VAR framework as in the previous DSA related approaches, and use Monte Carlo techniques to reveal the primary surplus that is required to keep the debt/GDP ratio from rising in all but the worst 50 percent, 25 percent, and 10 percent of circumstances. Di Bella (2008) proposes a framework for public debt sustainability analysis that include the estimation of an appropriate, and country-specific debt threshold, following the approach proposed by Reinhart, Rogoff & Savastano (2003).

Gray at al. (2008) paper proposes a new framework for the analysis of public sector debt sustainability, based on contingent claims analysis. By incorporating uncertainty into sovereign risk-adjusted balance sheets, this framework ties together DSA with early indicators of vulnerabilities. Giovanni & Gardner (2008) introduce DSA approach akin to that of Celasun at al. (2006), but instead of the baseline scenario around which confidence intervals are built they introduce adjustment scenario intended to reverse explosive debt dynamics. Finally, Kawakami & Romeu (2011), extend the work of Celasun at al. (2006) with the second-round effects of fiscal policy on macroeconomic projections. Their forecasting framework thus reflects the impact of the primary balance on the forecast of macro aggregates.

While the majority of the empirical research that apply FRF approach utilizes panels of countries to make “average” assessments of sustainability, stochastic DSA approach is typically based on the single-unit Vector Autoregression modeling, so that sample in these studies usually covers only one to five countries. Opposite to the FRF approach in empirical research wherein uniform criterion exists to make a conclusion about fiscal sustainability (which in case of FRF approach is obeying of fiscal reaction to fiscal rules), assessments about fiscal sustainability in research papers applying DSA approach are not based on some theoretically grounded and uniformed criterion. On the contrary, qualifications of fiscal sustainability in empirical papers are often based on rule of thumb, loose application of some subjectively chosen criterion, or sometimes even inconclusive (only forecast of the debt dynamics are presented) Therefore, strict systematization of the findings from DSA-wise empirical research to those that claims sustainability versus those which claims unsustainability is not possible to conduct. Instead, the Table 4.1 presents the overview of the empirical studies that apply stochastic DSA approach to fiscal sustainability assessment with simple description of the period and countries covered by the sample.

Table 4.1: Review of the empirical studies that apply stochastic DSA approach to fiscal sustainability assessment

Study	Sample coverage of the countries	Sample coverage of the period
Garcia & Rigobon (2004)	Brazil	1994-2003
Lewis (2004)	Jamaica	1996-2004
Debrun, Celasun & Ostry (2006)	Argentina, Brazil, Mexico, South Africa, Turkey	1990-2004
Penalver & Thwaites (2005)	Brazil	1999-2005
Tanner & Samake (2006)	Brazil, Mexico, Turkey	1995-2005
Di Bella (2008)	Dominican republic	1980-2007
Giovanni & Gardner (2008)	Lebanon	1998-2007
Kawakami & Romeu (2011)	Brazil	1995-2009
Abel & Kobor (2011)	Hungary	1995-2006
Zdravkovic & Bradic-Martinovic (2012), Zdravkovic (2013)	Serbia	2008-2012
Ferrarini & Ramayandi (2012)	Developing Asia	2000-2010
Eller & Urvova (2012)	Czech Republic, Hungary, Poland and Slovakia	1995-2011
Medeiros (2012)	EU	1976-2010
Cuerpo & Ramos (2015)	Spain	1986-2014

It can be noticed also that some of this studies were already discussed within FRF approach. These studies basically combines debt-stochastic modeling with FRF estimation to allow both stress testing (using stochastic simulation of shocks) and scenario analysis (using assumptions on future fiscal scenarios). Such approach is henceforth referred to as VAR-FRF DSA framework.

4.3 Critical assessment of existing literature

Putting all together, despite the considerable progress in development and improvement of the methodologies for the empirical assessment of the fiscal sustainability, broadly speaking existing literature has little said about following very important issues:

- **Out-of-sample performance.** Almost all of the literature which is dealing with stress testing of public debt based on the stochastic DSA approach makes projection of the future debt dynamics that goes beyond of historical data in the sample, so there is a little empirical evidence on the back testing and out-of-sample performance of this approach.

- **Likelihoods of scenarios and shocks.** Most of the models routinely imposed shocks simulation based on estimated historical variance-covariance matrix of the VAR residuals, assuming that shocks follows the joint normal distribution;
- **Compliance with market perception of risk.** Despite some of the models like Gray, Merton & Bodie (2007), Gapen at al. (2008) and Xu & Ghezzi (2003) model the sovereign spreads on government debt, majority of DSA related literature is not concerned with correlation of computed default probabilities with market spreads, except in Garcia & Rigobon (2004), Gray at al. (2008) and several other works;
- **Threshold levels of debt.** Except for Di Bella (2008) paper, DSA related literature is mostly concerned with estimation of probabilities of public debt evolution around baseline scenario without explicit assessment of debt threshold level.

5 DYNAMICS AND DECOMPOSITION OF THE PUBLIC DEBT OF SERBIA AND PEER COUNTRIES

The previous discussion reveals that reliability of fiscal sustainability assessment critically depends on the reliability of the macroeconomic assumptions used to produce forecast of the key debt determinants. While backward-looking analysis based on historical data can not provide full set of analytical inputs for the long-term debt forecasting, it remains starting point of the debt sustainability analysis in the mid run. Country-specific historical analysis of debt dynamics characteristics, such as debt structure, correlation patterns between macroeconomic variables and fiscal policy behavior, gives the solid ground which can be further utilized in forward-looking analysis of the fiscal sustainability.

This chapter provides analysis of the historical evolution of the public debt, debt dynamics' determinants and debt dynamics' composition, on the sample of eight Emerging European Countries henceforth referred as EEC 8. The main objective of the empirical analysis is comprehensive testing of the hypotheses 1 and 2:

- H1: Dynamics and cost of the public debt are correlated with change in non-fiscal and fiscal variables;
- H2: Dynamics and cost of the public debt are more sensitive to impact of fiscal than non-fiscal variables.

Sample naturally includes Serbia, while other seven peer countries from Emerging Europe are particularly selected for being EU members, geographically close and comparable with Serbia in terms economy, population and territorial size. The analysis covers annualized quarterly data mainly in the period 2000/01-2017, except in cases where data are available only for shorter time span. Since in this work two datasets are used in analysis, this one is referred as DS1. DS1 data sources and approach to annualization of the quarterly data are depicted in details in Annex 1.

The debt accumulation equation in relative terms (2.32) represents a milestone of this analysis, with several modifications in line with theoretical discussions in second and third chapter. These modifications include:

Use of implied interest rate as a debt dynamics' determinant. Since there is no natural aggregate interest rate that can be applied to accumulated debt, implied interest rate defined in (2.41) as $r_t = \frac{INT_t}{D_{t-1}}$ is used. As implied interest rate incorporates effects of the change in nominal exchange rate on debt dynamics, the DAE in (2.32) is then simplified to

$$d_t - d_{t-1} = \frac{r_t - \pi_t(1+rg_t) - rg_t}{(1+rg_t)(1+\pi_t)} d_{t-1} - pb_t + dd_t. \qquad (5.1)$$

Use of real exchange rate as a debt dynamics' determinant. Use of nominal foreign exchange would be a big limitation since only 4 out of EEC 8 has some form of floating exchange rate regime, while the other are either Euro zone members (Slovenia, Slovak Republic) or have some form of pegged regimes (Bulgaria, Croatia). Thus I use change in real effective exchange rates Δrfx_t as a debt determinant variable rather than nominal rate, This is in line with other similar work, as well as with equation (2.52) that depicts real exchange rate as a function of nominal exchange rate and domestic and foreign price levels.

Decomposition of public debt with respect to the cyclically-adjusted primary balance and potential GDP. Since the effects of the cyclical fluctuations affects the economic output in the mid run, use of potential GDP as a scaling factor in the DAE in relative terms is arguably more accurate approach from the standpoint of mid-term fiscal sustainability analysis. If the DAE is rescaled by the potential GDP instead of actual, primary balance as an contributor to debt dynamics can be decomposed to a cyclically-adjusted component $capb_t$ and an effect of automatic stabilizers, as_t . As being discussed previously, cyclically-adjusted primary balance is arguably better indication of the fiscal policy stance than actual balance.

Explicit incorporation of the economic cyclicality into the fiscal sustainability analysis imposes needs to pay special attention to the performance of the macroeconomic variables before and after the occurrence of the global economic crisis. The first quarter of 2009 is arbitrary chosen as a time point of crisis outbreak in EEC 8, since spillover of global crisis in the Western economies gradually spread over Eastern Europe economies. Indeed, descriptive analysis in the rest of this chapter confirms that dynamics of public debt and its determinants exhibit evident differences in dynamics prior and after the crisis.

5.1 Public debt dynamics analysis

Analysis of public debt dynamics of EEC 8 covers the period 2000-2017, except for Croatia and Serbia where available time series on debt are bit shorter. Public debt time series cover data on government debt according to the Maastricht definition, except in case of Serbia where data corresponds to the public debt definition stipulated by the Law on Public Debt for the reasons discussed in the first chapter. The individual dynamics of the public debt is presented in the Figure 5.1.

Figure 5.1: Public debt in EEC 8 – dynamics

Source: *DS1*

Public debt dynamics depicted in the Figure 5.1 shows that with notable exception of Bulgaria, other 7 countries followed the similar pattern in public debt dynamics: period of slight decrease or stagnation of indebtedness up to the late 2008, and then growth of public debt-to-GDP ratio till the end of period covered. This is more explicitly confirmed by the cross-country correlation structure of debt-to-GDP among EEC 8. In some cases, co-variations of public indebtedness between two countries exceeded 85%, like in case of Slovenia-Croatia or Slovenia-Serbia (Table 5.1b). Larger scales of government borrowings in the aftermath of the crisis leaves the average indebtedness of EEC 8 at 48%, around 11 pp higher than it was before the crisis (Table 5.1a) .

Table 5.1a Public debt in EEC 8 – descriptives

	BGR	HRV	CZE	HUN	SRB	ROU	SVK	SVN	Mean
Mean BC	44.53	38.73	25.56	59.32	42.98	19.34	40.73	26.31	37.19
Stdev BC	19.99	1.85	4.65	4.83	8.29	4.73	7.08	1.26	6.58
Min BC	16.32	35.50	15.32	51.93	29.70	11.43	29.14	22.83	26.52
Max BC	77.62	42.01	31.08	66.78	51.92	25.66	50.91	28.26	46.78
Mean AC	19.20	66.45	38.34	77.50	52.35	31.02	46.12	56.31	48.41
Stdev AC	6.13	16.42	5.40	4.39	16.48	9.18	9.79	21.95	11.22
Min AC	12.72	35.64	26.82	64.21	25.13	10.53	26.40	21.76	27.90
Max AC	29.49	86.19	45.55	83.46	75.17	39.10	57.66	83.87	62.56
Mean	30.62	54.63	32.58	69.31	49.88	25.75	43.69	42.79	43.66
Stdev	18.93	18.58	8.15	10.19	15.27	9.48	9.03	22.10	13.97
Min	12.72	35.50	15.32	51.93	25.13	10.53	26.40	21.76	24.91
Max	77.62	86.19	45.55	83.46	75.17	39.10	57.66	83.87	68.58

Source: *DS1, own calculation*

Table 5.1b Public debt in EEC 8 – cross-country correlation

	BGR	HRV	CZE	HUN	SRB	ROU	SVK	SVN
BGR	1.00	-0.37	-0.70	-0.79	0.65	-0.11	0.27	-0.30
HRV	-0.37	1.00	0.88	0.76	0.87	0.90	0.76	0.98
CZE	-0.70	0.88	1.00	0.85	0.65	0.75	0.46	0.77
HUN	-0.79	0.76	0.85	1.00	0.32	0.58	0.24	0.67
SRB	0.65	0.87	0.65	0.32	1.00	0.79	0.87	0.90
ROU	-0.11	0.90	0.75	0.58	0.79	1.00	0.90	0.86
SVK	0.27	0.76	0.46	0.24	0.87	0.90	1.00	0.73
SVN	-0.30	0.98	0.77	0.67	0.90	0.86	0.73	1.00

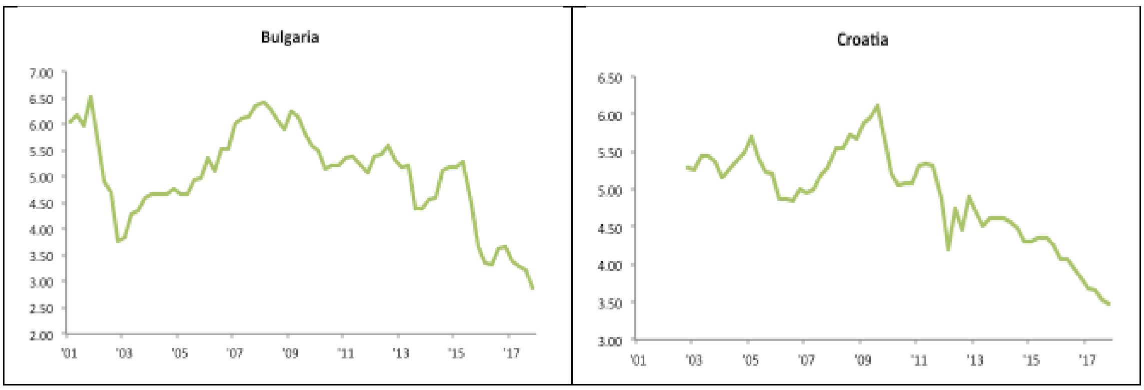
Source: *DS1, own calculation*

5.2 Analysis of the non-fiscal public debt determinants

The non-fiscal drivers of public debt include implied real interest rate, real GDP growth, real effective exchange rates and inflation (based on GDP deflator). In this section I discuss stylized facts on non-fiscal drivers in EEC 8, including dynamic, descriptive statistics and cross-country correlation.

5.2.1 Interest rate

During the period 2001-2017, implied interest rates steadily decline in most of EEC 8 countries, except in Serbia (Figure 5.2). In some countries decline was especially emphasized up to 2004. Within the crisis window there was a tendency of increase in interest rates, especially in Bulgaria, Croatia and Romania, but this trend was only temporary and gradually faded in the crisis aftermath.



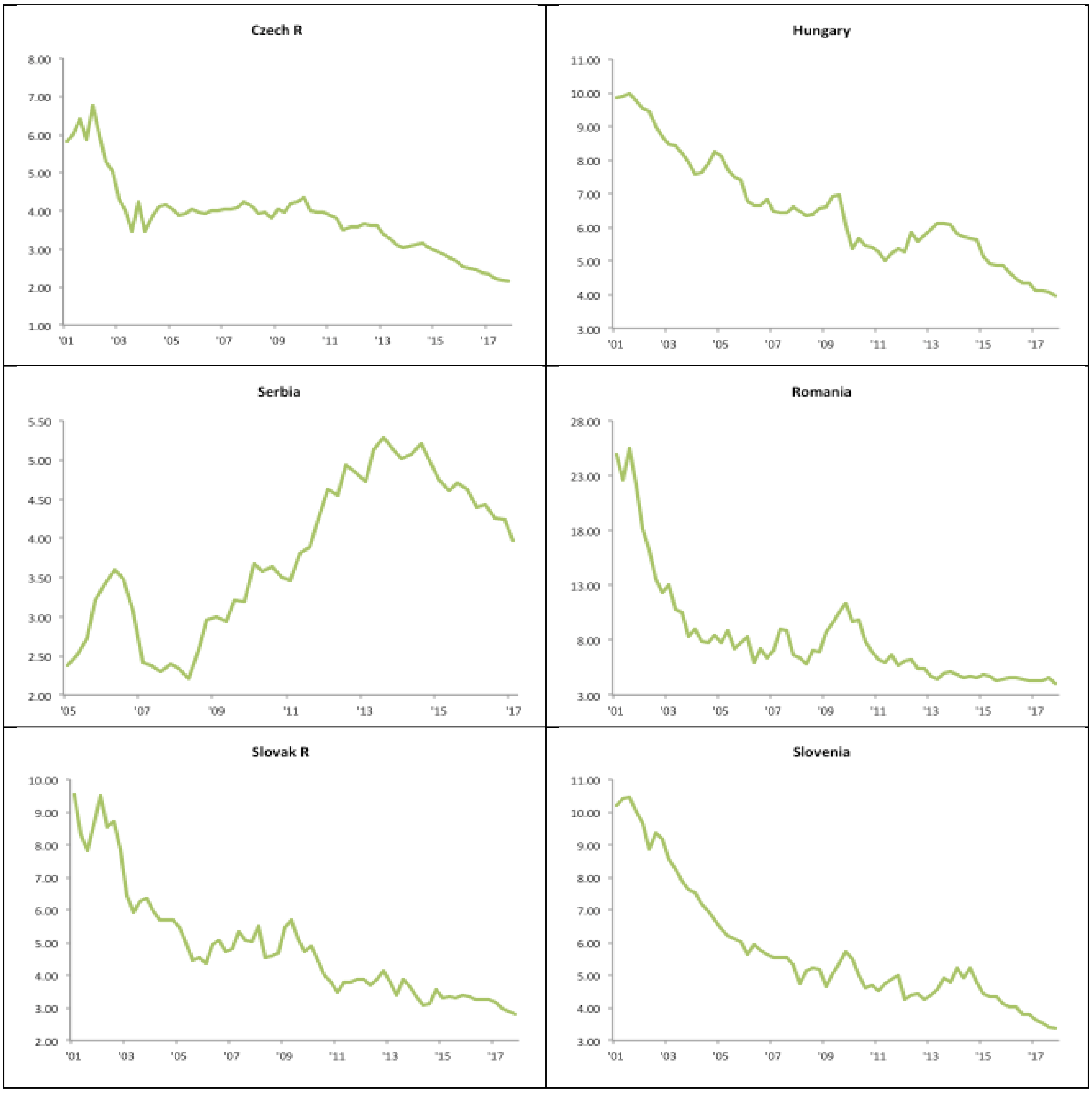


Figure 5.2: Implied interest rate in EEC 8 – dynamic

Source: *DS1, own calculation*

On average, implied interest rate in post-crisis period dropped for 1.7 pp, from 6.2% to 4.5% (Table 5.2a). Also, the volatility of interest rates, measured by standard deviation, seems to decline in the aftermath of crisis, from 1.67% to only 0.9%. In general, interest rate seems to be the most stable macroeconomic variable, having the lowest level of volatility among the other macroeconomic variables. The cross-country correlation is very exhibited in EU member states – correlation coefficients mostly exceeded 0.75 (Table 5.2b), with exception of Bulgarian and Croatian, which interest rates are less correlated with other EU countries in the sample. On the other side, Serbian implied interest rates seems to be negatively correlated with rates of EU member states, which is probably caused by the specific structure of the Serbian public debt. In the early 2000's, Serbian public debt was reprogrammed and some interest payments were written off. In addition, Serbian debt portfolio was dominated by the concessional loans contracted at interest rates lower than those at the market. Following a progress of Serbian integration into EU financial space and changes in debt portfolio structure in a favor of market debt instruments, interest rates on government borrowing have been gradually rising and converging to the market values comparable to other EU countries.

Table 5.2a: Implied interest rate in EEC 8 – descriptives

	BGR	HRV	CZE	HUN	SRB	ROU	SVK	SVN	Mean
Mean BC	5.30	5.28	4.46	7.81	2.78	10.89	6.10	7.15	6.22
Stdev BC	0.80	0.26	0.90	1.22	0.50	5.75	1.60	1.82	1.61
Min BC	3.77	4.85	3.44	6.34	2.29	5.88	4.39	4.75	4.46
Max BC	6.51	5.73	6.76	9.96	3.60	25.50	9.53	10.45	9.76
Mean AC	4.76	4.64	3.25	5.35	4.15	5.93	3.74	4.52	4.54
Stdev AC	0.91	0.68	0.65	0.77	0.83	2.05	0.70	0.58	0.90
Min AC	2.87	3.47	2.15	3.97	2.21	4.02	2.82	3.38	3.11
Max AC	6.25	6.10	4.36	6.95	5.30	11.38	5.70	5.73	6.47
Mean	5.01	4.90	3.82	6.51	3.79	8.27	4.85	5.76	5.36
Stdev	0.90	0.63	0.98	1.59	0.96	4.87	1.69	1.86	1.68
Min	2.87	3.47	2.15	3.97	2.21	4.02	2.82	3.38	3.11
Max	6.51	6.10	6.76	9.96	5.30	25.50	9.53	10.45	10.01

Source: *DS1, own calculation*

Table 5.2b: Implied interest rate in EEC 8 - cross-country correlation

	BGR	HRV	CZE	HUN	SRB	ROU	SVK	SVN
BGR	1.00	0.65	0.59	0.37	-0.61	0.38	0.36	0.25
HRV	0.65	1.00	0.86	0.74	-0.73	0.73	0.73	0.60
CZE	0.59	0.86	1.00	0.87	-0.75	0.88	0.90	0.86
HUN	0.37	0.74	0.87	1.00	-0.60	0.83	0.93	0.95
SRB	-0.61	-0.73	-0.75	-0.60	1.00	-0.73	-0.81	-0.54
ROU	0.38	0.73	0.88	0.83	-0.73	1.00	0.89	0.89
SVK	0.36	0.73	0.90	0.93	-0.81	0.89	1.00	0.94
SVN	0.25	0.60	0.86	0.95	-0.54	0.89	0.94	1.00

Source: *DS1, own calculation*

5.2.2 Real growth

Similar to other EEC countries, EEC 8 also experienced a period of fast growth interrupted by the crisis, when actual growth rates significantly dropped never recovering to pre-crisis values (Figure 5.3). Thus, structural breaks in GDP growth time series in crisis window are visible for all EEC 8. With notable exemption of Poland, other countries experienced sharp recession with GDP fall in crisis time. Beside actual growth rates, potential growth rates based on the estimation of potential GDP, are also presented in the Figure 5.3. Potential GDP for EEC 8, with an exception of Hungary, is estimated using Kalman numerical solution to the state-space representation of the economic output, given in (2.55). Potential GDP for Hungary is computed using HP filtering applied to the state-space representation of the economic output as in (2.56), since procedure of Kalman filtering failed to find numerical solution in case of Hungarian GDP data. Potential growth rates partially mitigate cyclical effects on GDP growth, but it seems that fall in economic activity in post-crisis period was structural, heavily damaging growth potentials of the EEC 8.

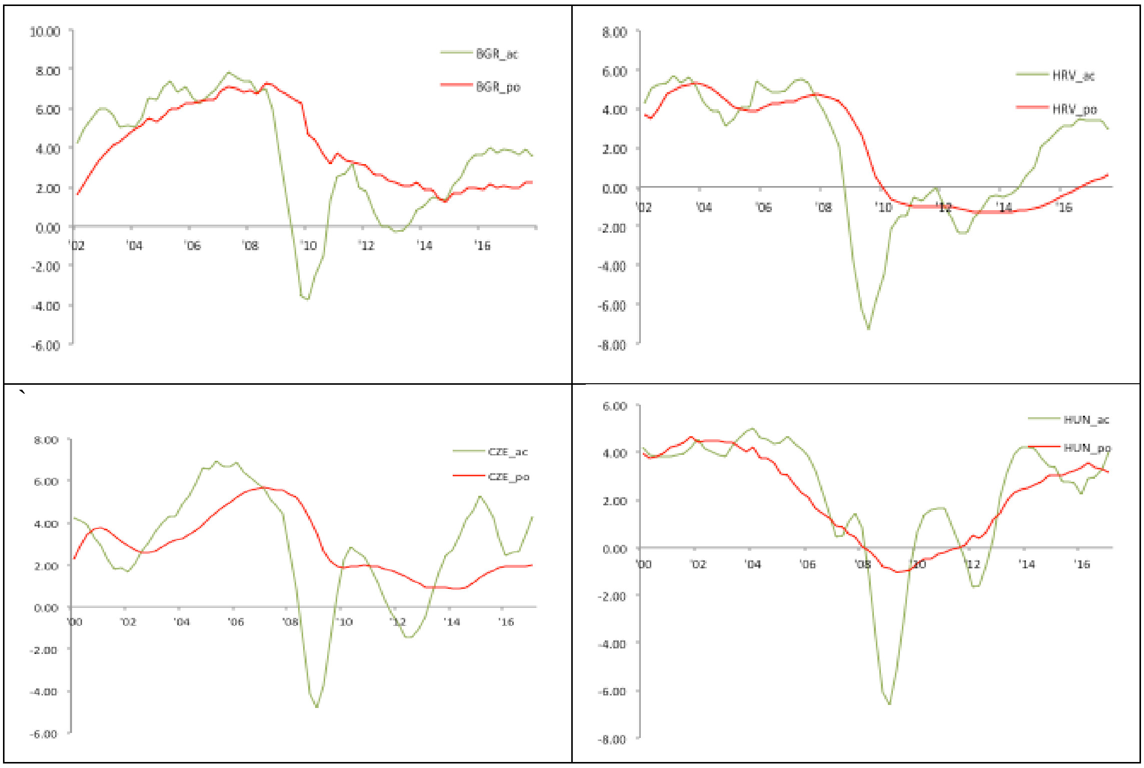


Figure 5.3: Potential and actual real growth rates in EEC 8 - dynamic
Source: *DS1, own calculation*

Average actual growth rates dropped for more than 4 pp, going from impressive 5.2% in pre-crisis period to only 1% in post-crisis period (Table 5.3a), and volatility of growth also increased. Cross-country correlations of GDP growth rates were also pronounced – in most cases they exceeded 0.7 (Table 5.3b).

Table 5.3a: Actual real growth rates in EEC 8 - descriptives

	BGR	HRV	CZE	HUN	SRB	ROU	SVK	SVN	Mean
Mean BC	6.07	4.51	4.47	3.53	6.06	6.23	6.25	4.35	5.18
Stdev BC	1.19	0.91	1.70	1.36	2.11	1.64	2.37	1.31	1.57
Min BC	3.56	2.04	1.65	0.43	0.55	2.64	2.34	2.80	2.00
Max BC	7.85	5.66	6.91	5.00	10.11	9.33	10.80	7.13	7.85
Mean AC	1.51	-0.43	1.27	0.92	0.49	1.87	2.09	0.21	0.99
Stdev AC	2.15	2.82	2.59	2.98	1.70	3.35	2.27	3.29	2.64
Min AC	-3.77	-7.29	-4.80	-6.60	-3.12	-5.95	-5.42	-7.80	-5.59
Max AC	4.00	3.54	5.31	4.23	2.80	6.97	5.04	4.88	4.60
Mean	3.66	1.78	2.78	2.15	2.13	3.92	4.05	2.16	2.83
Stdev	2.88	3.29	2.72	2.69	3.06	3.45	3.11	3.28	3.06
Min	-3.77	-7.29	-4.80	-6.60	-3.12	-5.95	-5.42	-7.80	-5.59
Max	7.85	5.66	6.91	5.00	9.88	9.33	10.80	7.13	7.82

Source: *DS1, own calculation*

Table 5.3b: Actual real growth rates in EEC 8 – cross-country correlation

	BGR	HRV	CZE	HUN	SRB	ROU	SVK	SVN
BGR	1.00	0.91	0.87	0.68	0.84	0.86	0.88	0.90
HRV	0.91	1.00	0.83	0.81	0.79	0.86	0.83	0.90
CZE	0.87	0.83	1.00	0.77	0.60	0.73	0.85	0.92
HUN	0.68	0.81	0.77	1.00	0.56	0.70	0.57	0.79
SRB	0.84	0.79	0.60	0.56	1.00	0.73	0.69	0.68
ROU	0.86	0.86	0.73	0.70	0.73	1.00	0.75	0.82
SVK	0.88	0.83	0.85	0.57	0.69	0.75	1.00	0.89
SVN	0.90	0.90	0.92	0.79	0.68	0.82	0.89	1.00

Source: *DS1, own calculation*

5.2.3. Exchange rate

Dynamics of real effective exchange rate (REER) is characterized by the period or pre-crisis appreciation fueled by the large foreign capital inflows creating external imbalances, that was corrected by the post-crisis depreciation (Figure 5.4).

Figure 5.4: Real effective exchange rates in EEC 8 - dynamics
Source: *DS1, own calculation*

Among the other non-fiscal determinants of public debt, change in REER is the most volatile variable, which volatility is persistently high throughout total observed period (Table 5.4a). Average growth rate of REER in pre-crisis period dropped for almost 5 pp, from 4.4% appreciation rate to 0.5% percent depreciation rate in post-crisis period. Cross-country correlation is rather lower than in case of other non-fiscal variables, yet somewhat higher correlation is exhibited between countries that adopted EUR or have currency pegged to EUR (Table 5.4b).

Table 5.4a: Real effective exchange rates in EEC 8 - dynamic

	BGR	HRV	CZE	HUN	SRB	ROU	SVK	SVN	Mean
Mean BC	4.72	1.90	6.12	5.11	6.08	3.69	6.77	0.78	4.40
Stdev BC	2.75	1.51	5.68	6.49	6.45	7.28	4.86	1.45	4.56
Min BC	-0.31	-0.68	-4.84	-8.79	-1.98	-6.51	-1.02	-1.67	-3.22
Max BC	12.15	5.28	19.23	15.71	17.74	21.63	15.70	3.29	13.84
Mean AC	0.17	-0.72	-0.46	-1.44	-0.43	-0.86	0.23	-0.34	-0.48
Stdev AC	2.63	2.18	4.37	5.04	6.77	4.18	3.52	1.65	3.79
Min AC	-4.61	-5.46	-6.72	-10.59	-12.68	-9.25	-4.75	-4.26	-7.29
Max AC	6.15	2.58	9.85	12.58	14.81	7.46	14.56	2.28	8.78
Mean	2.22	0.46	2.51	1.51	2.05	1.19	3.18	0.16	1.66
Stdev	3.51	2.30	5.96	6.58	7.33	6.18	5.28	1.65	4.85
Min	-4.61	-5.46	-6.72	-10.59	-12.68	-9.25	-4.75	-4.26	-7.29
Max	12.15	5.28	19.23	15.71	17.74	21.63	15.70	3.29	13.84

Source: *DS1, own calculation*

Table 5.4b: Real effective exchange rates in EEC 8 – cross-country correlation

	BGR	HRV	CZE	HUN	SRB	ROU	SVK	SVN
BGR	1.00	0.78	0.61	0.38	0.58	-0.01	0.70	0.69
HRV	0.78	1.00	0.61	0.42	0.44	0.12	0.49	0.64
CZE	0.61	0.61	1.00	0.57	0.57	0.18	0.15	0.42
HUN	0.38	0.42	0.57	1.00	0.48	0.27	0.27	0.33
SRB	0.58	0.44	0.57	0.48	1.00	0.34	0.44	0.54
ROU	-0.01	0.12	0.18	0.27	0.34	1.00	0.03	-0.05
SVK	0.70	0.49	0.15	0.27	0.44	0.03	1.00	0.60
SVN	0.69	0.64	0.42	0.33	0.54	-0.05	0.60	1.00

Source: *DS1, own calculation*

5.2.4 Inflation

Similar to implied interest rates, inflation rates (computed from GDP deflator) exhibit the same tendency of steady decline during the observed period, with moderate temporary increase in crisis window (Figure 5.5). Some countries also experienced short-term disinflation in the post-crisis period.

Figure 5.5: Inflation rates (GDP deflator) in EEC 8 - dynamic

Source: *DS1, own calculation*

Average inflation rate felt from 7.4% in pre-crisis to 2.3% in post-crisis period, and also became more stable as volatility almost halved (Table 5.5a). Cross-country correlation is also present as most of correlation coefficients exceed 0.5, but apparently lower than in case of interest or growth rates (Table 5.5b).

Table 5.5a: Inflation rates (GDP deflator) in EEC 8 - descriptives

	BGR	HRV	CZE	HUN	SRB	ROU	SVK	SVN	Mean
Mean BC	6.17	3.96	2.35	6.09	11.46	20.55	4.06	4.73	7.42
Stdev BC	2.34	0.63	1.52	2.92	2.01	9.64	1.97	2.28	2.91
Min BC	2.27	3.14	-0.60	0.99	8.22	10.04	1.07	1.18	3.29
Max BC	11.09	5.75	5.17	11.72	14.48	42.89	8.81	8.68	13.57
Mean AC	2.33	1.14	1.17	2.77	5.42	3.93	0.37	1.21	2.29
Stdev AC	2.54	1.35	1.10	0.80	2.65	2.39	0.83	1.29	1.62
Min AC	-1.97	-0.17	-1.43	0.96	1.98	1.36	-1.16	-0.99	-0.18
Max AC	8.66	5.50	2.81	4.40	9.86	13.56	1.70	4.75	6.40
Mean	4.13	2.40	1.72	4.33	7.07	11.75	2.11	2.86	4.55
Stdev	3.10	1.78	1.43	2.66	3.68	10.76	2.36	2.53	3.54
Min	-1.97	-0.17	-1.43	0.96	1.98	1.36	-1.16	-0.99	-0.18
Max	11.09	5.75	5.17	11.72	14.48	42.89	8.81	8.68	13.57

Source: *DS1, own calculation*

Table 5.5b: Inflation rates (GDP deflator) in EEC 8 – cross-country correlation

\	BGR	HRV	CZE	HUN	SRB	ROU	SVK	SVN
BGR	1.00	0.78	0.26	0.35	0.60	0.46	0.38	0.40
HRV	0.78	1.00	0.38	0.59	0.82	0.75	0.65	0.69
CZE	0.26	0.38	1.00	0.58	-0.10	0.56	0.33	0.72
HUN	0.35	0.59	0.58	1.00	0.57	0.92	0.75	0.86
POL	0.60	0.82	-0.10	0.57	1.00	0.77	0.73	0.55
ROU	0.46	0.75	0.56	0.92	0.77	1.00	0.86	0.90
SVK	0.38	0.65	0.33	0.75	0.73	0.86	1.00	0.67
SVN	0.40	0.69	0.72	0.86	0.55	0.90	0.67	1.00

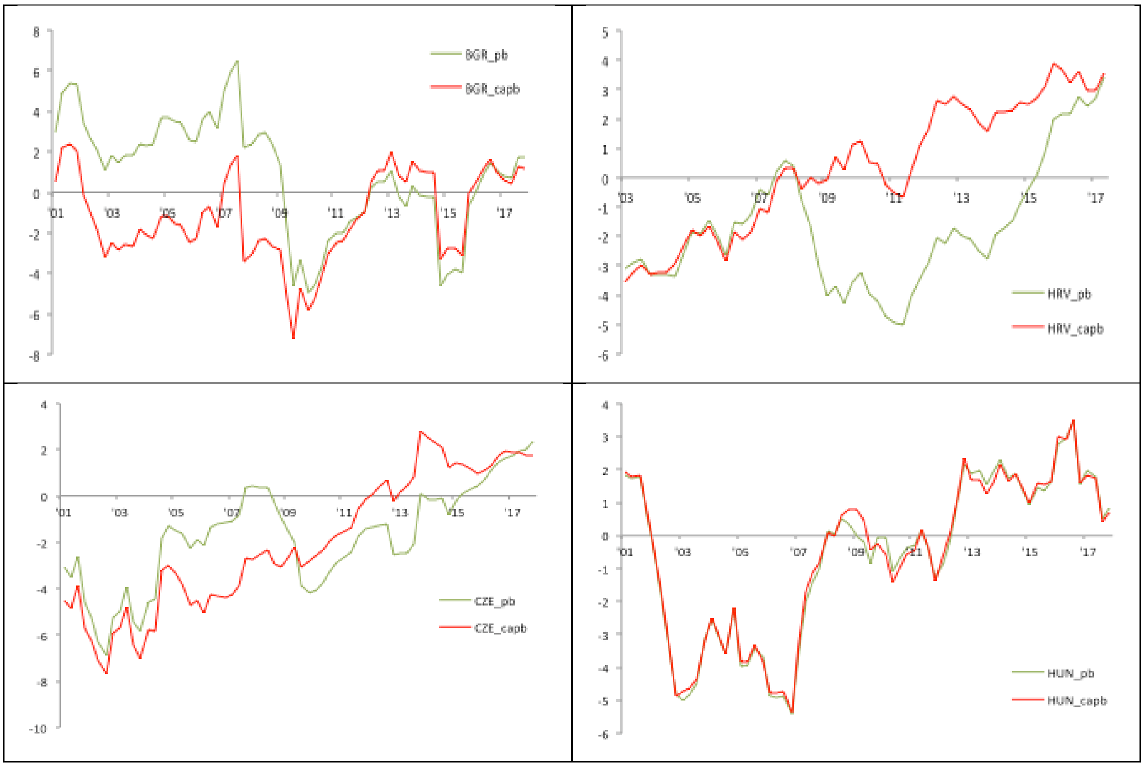
Source: *DS1, own calculation*

5.3 Analysis of the fiscal public debt determinants

In previous chapters I have already discussed importance of difference between primary balance from non-fiscal variables in the context of debt sustainability assessment. Being more exogenous to external spillovers and under control of fiscal authorities, primary balance is expected to be more country-specific and thus less correlated between the countries. In addition, debt-deficit adjustments should be also country-specific, reflecting individual issues and policy actions to preserve economic stability.

5.3.1 Primary balance

Similar to real growth, primary balance in the most of EEC 8 also displayed structural breaks that occur in the crisis window, when trends of primary surpluses or declining deficits turned to persistent primary deficits that gradually improved in the crisis aftermath (Figure 5.6). The exceptions were Hungary and Serbia; Hungary struggled with large deficits that were the subject of Excessive Deficits Procedure long time before the crisis emergence, while Serbian fiscal consolidation was belated relative to other EEC 8. Based on equation (3.15), I computed cyclically-adjusted primary balances to correct them for effects of automatic stabilizers. Effects of automatic stabilizers varied in size among the EEC 8 countries, but had expected patterns: before the crisis, they were positive increasing actual balance, while in the crisis aftermath they turned to negative values eventually getting close to zero by the end of covered period.



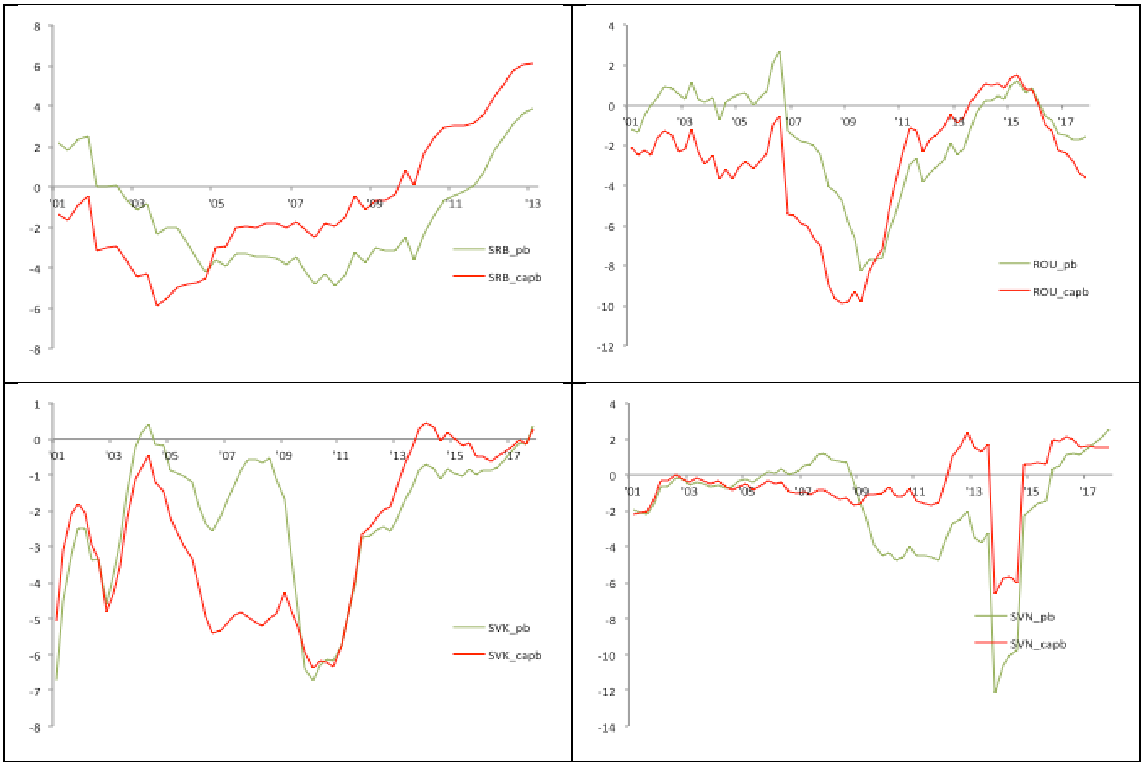


Figure 5.6: Cyclically-adjusted and actual primary balance in EEC 8 - dynamic
Source: *DS1, own calculation*

On average, EEC 8 recorded primary deficits both in pre- and post-crisis period, but average value in post-crisis period was almost 1 pp lower than in pre-crisis period (Table 5.6a). On the other hand, volatility of primary balance did not change substantially. As expected, cross-country correlations are considerably lower than in case of growth or interest rate, only occasionally exceeding 0.5 (Table 5.6b).

Table 5.6a: Actual primary balance in EEC 8 - descriptives

	BGR	HRV	CZE	HUN	SRB	ROU	SVK	SVN	Mean
Mean BC	3.20	-1.78	-2.65	-2.21	-0.01	-0.49	-2.04	-0.30	-0.78
Stdev BC	1.32	1.27	2.13	2.37	1.73	1.70	1.91	0.86	1.66
Min BC	1.06	-3.38	-6.92	-5.42	-2.33	-4.72	-8.02	-2.20	-3.99
Max BC	6.48	0.60	0.42	2.23	2.49	2.72	0.41	1.16	2.06
Mean AC	-1.09	-1.67	-0.96	0.92	-2.14	-2.54	-2.38	-2.98	-1.60
Stdev AC	2.10	2.48	1.88	1.25	2.50	2.80	2.14	3.56	2.34
Min AC	-4.97	-5.01	-4.22	-1.27	-4.94	-8.32	-6.71	-12.12	-5.94
Max AC	1.76	3.42	2.35	3.49	3.89	1.18	0.35	2.53	2.37
Mean	0.96	-1.71	-1.77	-0.57	-1.57	-1.56	-2.22	-1.70	-1.27
Stdev	2.78	2.09	2.16	2.43	2.49	2.54	2.02	2.95	2.43
Min	-4.97	-5.01	-6.92	-5.42	-4.94	-8.32	-8.02	-12.12	-6.96
Max	6.48	3.42	2.35	3.49	3.89	2.72	0.41	2.53	3.16

Source: *DS1, own calculation*

Table 5.6b: Actual primary balance in EEC 8 – cross-country correlations

	BGR	HRV	CZE	HUN	SRB	ROU	SVK	SVN
BGR	1.00	0.30	-0.02	-0.32	0.53	0.45	0.31	0.47
HRV	0.30	1.00	0.78	0.40	0.74	0.26	0.60	0.58
CZE	-0.02	0.78	1.00	0.46	0.64	0.05	0.53	0.14
HUN	-0.32	0.40	0.46	1.00	-0.25	-0.22	0.01	-0.29
POL	0.53	0.74	0.64	-0.25	1.00	0.50	0.52	0.66
ROU	0.45	0.26	0.05	-0.22	0.50	1.00	0.48	0.22
SVK	0.31	0.60	0.53	0.01	0.52	0.48	1.00	0.31
SVN	0.47	0.58	0.14	-0.29	0.66	0.22	0.31	1.00

Source: *DS1, own calculation*

5.3.2 Debt-deficit (stock-flow) adjustments

The debt-deficit adjustments in EEC 8 were quite large, frequently accounting 5 and more percentage points of debt increment (Figure 5.7). This is not a surprising result, as study of Campos, Jaimovich and Panizza (2006) show that fiscal deficits often account only small fraction of debt changes. Despite the authors' efforts to find common factors that can explain dynamics of debt-deficit adjustments, they succeed only to explain 20% of the within-country variations in adjustments.

Figure 5.7: Debt-deficit adjustment in EEC 8 – dynamic

Source: *DS1, own calculation*

Debt-deficit adjustments in EEC 8 on average was debt reducing in pre-crisis period and debt-enhancing in post-crisis period (Table 5.7a). Cross-country correlations were low and often negative (Table 5.7b), confirming findings from previous discussion that debt-deficit adjustments are the most country-specific components of debt dynamic.

Table 5.7a: Debt-deficit adjustment in EEC 8 - descriptives

	BGR	HRV	CZE	HUN	SRB	ROU	SVK	SVN	Mean
Mean BC	-1.96	-0.45	-0.56	-0.14	-1.26	0.72	-3.15	-0.09	-0.86
Stdev BC	3.55	1.19	1.69	1.76	5.22	2.76	3.23	0.98	2.55
Min BC	-9.41	-2.92	-3.32	-3.31	-8.19	-3.42	-9.64	-1.55	-5.22
Max BC	4.99	1.67	3.81	6.07	8.98	6.87	2.65	2.79	4.73
Mean AC	0.27	0.76	-0.11	0.61	2.73	0.42	-0.05	2.08	0.84
Stdev AC	2.93	2.13	1.51	3.84	3.28	1.03	2.80	3.34	2.61
Min AC	-5.36	-4.33	-3.59	-7.67	-5.40	-1.27	-4.97	-4.19	-4.60
Max AC	6.30	5.84	3.04	12.79	9.57	3.01	6.28	10.85	7.21
Mean	-0.78	0.26	-0.32	0.26	1.61	0.56	-1.51	1.06	0.14
Stdev	3.40	1.89	1.60	3.05	4.27	2.03	3.37	2.73	2.79
Min	-9.41	-4.33	-3.59	-7.67	-8.19	-3.42	-9.64	-4.19	-6.31
Max	6.30	5.84	3.81	12.79	9.57	6.87	6.28	10.85	7.79

Source: *DS1, own calculation*

Table 5.7b Debt-deficit adjustment in EEC 8 – cross-country correlation

	BGR	HRV	CZE	HUN	SRB	ROU	SVK	SVN
BGR	1.00	-0.29	0.25	-0.05	-0.06	-0.23	0.30	0.09
HRV	-0.29	1.00	-0.02	0.24	0.26	0.17	0.13	0.27
CZE	0.25	-0.02	1.00	-0.15	-0.31	-0.01	0.25	-0.28
HUN	-0.05	0.24	-0.15	1.00	0.02	-0.06	-0.07	0.23
POL	-0.06	0.26	-0.31	0.02	1.00	0.46	0.16	0.06
ROU	-0.23	0.17	-0.01	-0.06	0.46	1.00	-0.18	0.04
SVK	0.30	0.13	0.25	-0.07	0.16	-0.18	1.00	0.15
SVN	0.09	0.27	-0.28	0.23	0.06	0.04	0.15	1.00

Source: *DS1, own calculation*

5.4 Contribution of the determinants to public debt dynamics

Following the introductory notes in this chapter, the final form of the DAE used to decompose the debt reads as

$$d_t^p - d_{t-1}^p = \frac{r_t - \pi_t(1+rg_t^p) - rg_t^p}{(1+rg_t^p)(1+\pi_t)} d_{t-1}^p - capb_t^p - as_t^p + dd_t^p, \tag{5.2}$$

where the superscript p means that the variable is rescaled by potential GDP and where rg_t^p is the growth rate of potential GDP. Based on equation (5.2), we can isolate five main drivers of the public debt dynamics, namely the contributions of:

- the real implied interest rate reflecting the influence of the financial market variables;
- the potential real growth rate reflecting the influence of the long-term production capacities, i.e. trend of economic output;
- the cyclically-adjusted primary balance reflecting the fiscal policy stance;
- the automatic stabilizers reflecting the influence of the economic cyclicality;
- the debt-deficit adjustment reflecting a residual between overall fiscal balance (sum of all four previous components) and recorded change in government liabilities.

Since debt-deficit adjustments are primarily one-off transactions, and automatic stabilizers reflects temporary fluctuations of the economic output, removal of these two components results in debt-to-potential GDP ratio that I considered to be the closest possible “structural” measure of change in public indebtedness that should be used to assess fiscal sustainability over mid- to long run. Hereafter, I used term adjusted change in debt to denote value of change in public debt scaled by the potential GDP after removal of cyclical and debt-deficit adjustment component.

Following the DAE (5.2), in this section we present decomposition of the public debt increments (in percentage points) to non-fiscal, fiscal, cyclical and residual contributions. Series of figures 5.8a to 5.8h present quarterly decomposition of public debt annualized changes for each EEC 8 country. Black line in the figures (*debt_dif*) shows values of debt change Δd_t^p , while red line (*debt_adj_dif*) shows values of change in structural indebtedness, $\Delta sd_t^p = \Delta d_t^p + as_t^p - dd_t^p$. The contributions of real implied interest rate, real growth, cyclically-adjusted primary balance, automatic stabilizers and debt-deficit adjustments in the figures are denoted as *ir_cont*, *rg_cont*, *ca_pb_cont*, *as_cont* and *dd_cont*, respectively.

Bulgaria (Figure 5.8a)

The debt increments in Bulgaria were negative in the pre-crisis period, imposing steady decline in public debt. Automatic stabilizers and debt-deficit adjustments were the main sources of debt decline in terms of contribution size, which resulted in a big discrepancy between actual and structural debt dynamics. Since the crisis outbreak, effects of stabilizers gradually faded, while debt-reducing effects of DDA were offset with increasing values of CA primary deficits. As a result, debt increments were mainly positive in the crisis aftermath. Contribution of interest rates and growth seems to be quite smaller relative to other drivers. Throughout the total period observed, structural debt increment was mostly neutral (around zero), except in crisis window, implying that indebtedness of Bulgaria didn't change substantially.

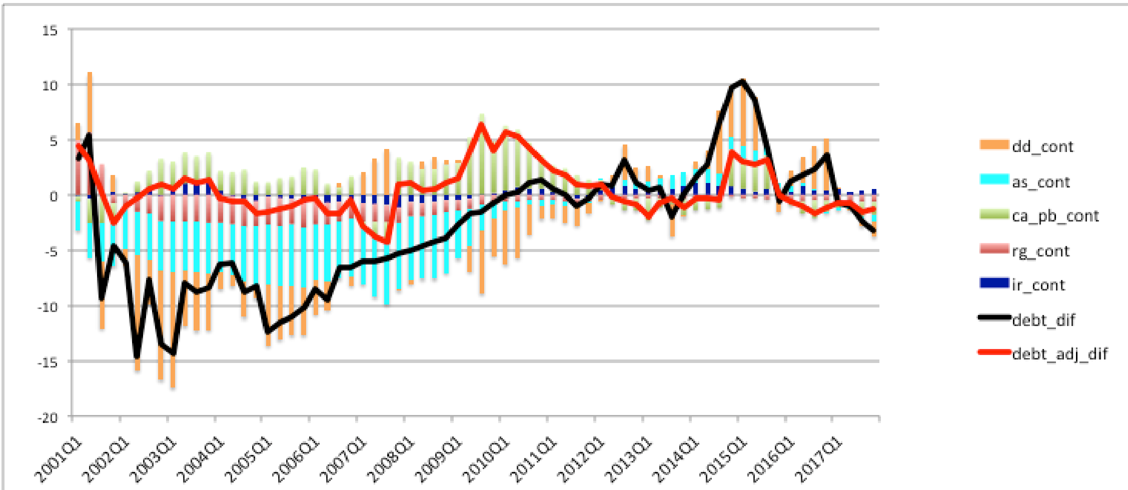


Figure 5.8a: Public debt growth decomposition – Bulgaria

Source: *DS1, own calculation*

Croatia (Figure 5.8b)

Due to the limited data available for some variables, decomposition of debt is possible only apply in the period 2004-2017. In the pre-crisis period, bot actual and structural debt increments were close to zero, as debt dynamics' contributions were offsetting each other. By the end of 2008, debt increments rapidly increased, since all debt drivers had a positive contribution to debt incremental. In the period surrounding crisis, the biggest contributors were CA primary deficits and automatic stabilizers, but over time they faded and significance of real interest rate to debt dynamics increased. This results in divergence of the actual debt increments above structural values. Eventually, in 2016 and 2017 CAPB went to surplus bringing back neutral debt dynamics.

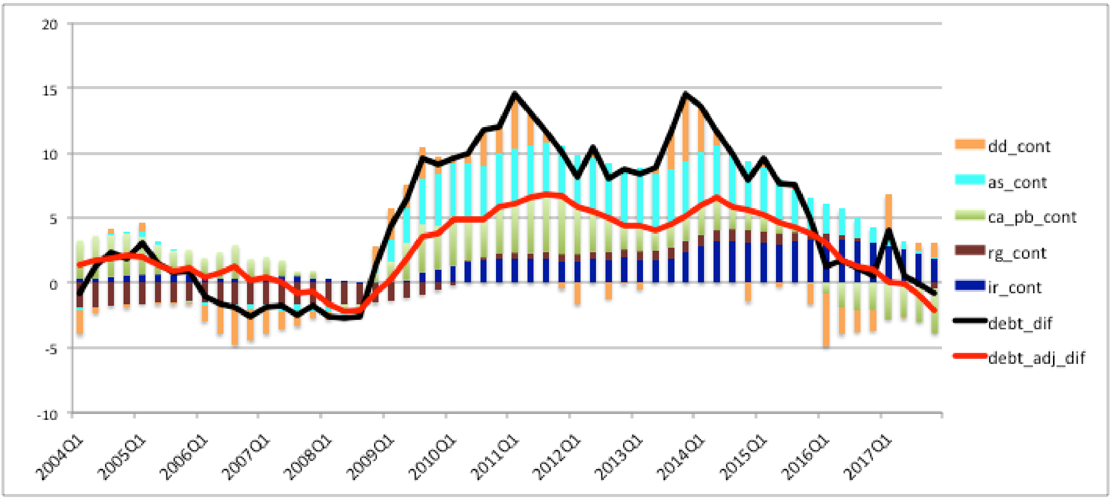


Figure 5.8b: Public debt growth decomposition – Croatia
Source: *DS1, own calculation*

Czech Republic (Figure 5.8c)

In the pre-crisis period Czech Republic was generating large primary deficits, which effects on debt dynamics were partially compensated by the cyclical effects of automatic stabilizers and debt-deficit adjustments. Therefore, structural debt increments were exceeding actual values most of the time prior to 2009. Since crisis outbreak, primary deficits were gradually reduced and eventually turned into surpluses, reverting the trend of rising positive debt increments in the first couple of post-crisis years. It is also remarkable that structural values of debt increments steadily decline over the total period covered by the sample. The contributions of other debt determinants were considerably smaller, with somewhat higher negative contribution of real growth in pre-crisis and positive contribution of interest rates at the beginning of post-crisis period.

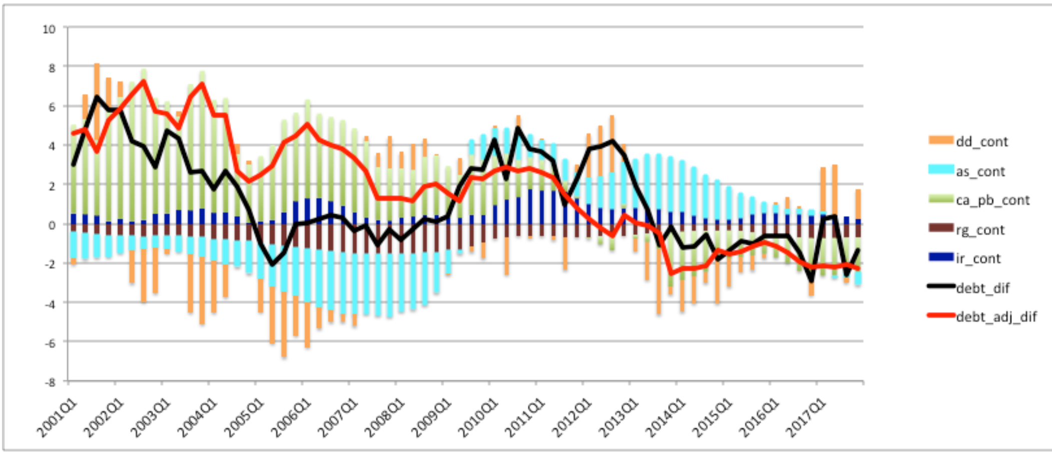


Figure 5.8c: Public debt growth decomposition - Czech Republic
Source: *DS1, own calculation*

Hungary (Figure 5.8d)

Hungary was the only EEC 8 country running high public debt throughout the whole observed period. Except in the crisis window wherein large debt-deficit contributions strongly pushed debt up, debt increments were stable swinging between the range of -5 to 5 percentage points, both in actual and structural terms. The most persistent contributions to public debt dynamics came from interest rate and real growth, which tended to offset each other. Thus, structural dynamics is apparently correlated with swings of CA primary balance apart from crisis window.

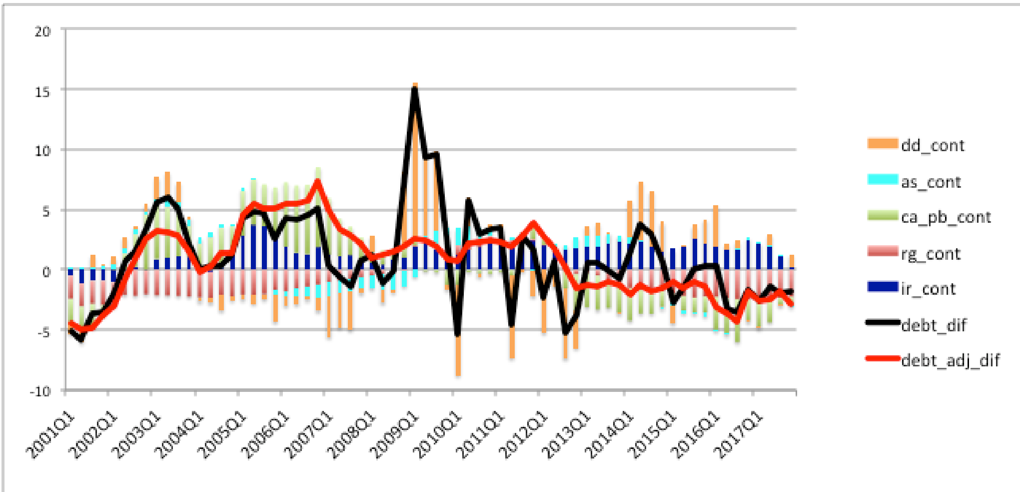


Figure 5.8d: Public debt growth decomposition – Hungary
Source: *DS1, own calculation*

Serbia (Figure 5.8e)

The public debt dynamics in Serbia in pre-crisis period is characterized by unusually negative contribution of interest rate, which is probably consequence of the real negative interest rate during the period of debt reprogramming. Yet, during time size of those contributions faded and eventually turned to be positive as expected. The contribution of other determinants are in line with expectations; automatic stabilizers opposed contributions of the CA primary balance, so that actual debt increments mostly coincided with debt-deficit adjustments. The disappearance of the large contributions of debt-deficit adjustments corresponds with period of fiscal consolidation and more credible fiscal policy, leading to fall in both actual and structural indebtedness.

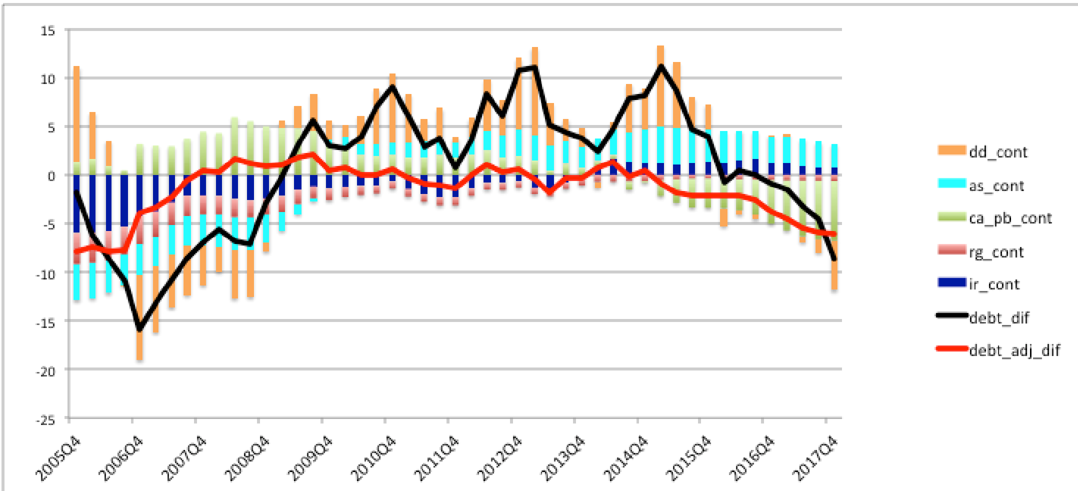


Figure 5.8e: Public debt growth decomposition – Serbia
Source: *DS1, own calculation*

Romania (Figure 5.8f)

The contributions of the interest rate to debt dynamics in Romania followed the similar pattern as in Serbia during the pre-crisis period, in line with the fact that Romanian inflation rate was high above the implied interest rate. On the other hand, contribution of CA primary balance in the pre-crisis period was minor, opposite to the very emphasized automatic stabilizers that kept debt increments negative. In the aftermath of the crisis situation overturned as CA primary balance became overwhelming contributor to debt increment. Eventually, all contributions of all debt determinants shrank stabilizing the debt dynamics.

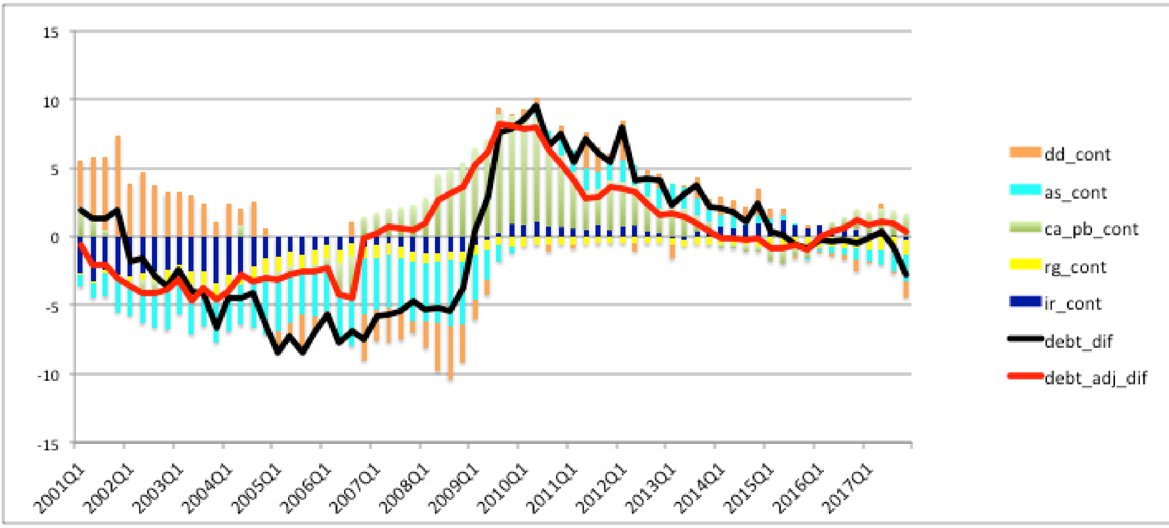


Figure 5.8f: Public debt growth decomposition – Romania
Source: *own calculation*

Slovak Republic (Figure 5.8g)

Deficit-debt adjustments and automatic stabilizers played important role in reduction of public debt of Slovak Republic, offsetting growing positive contributions of CA primary deficits to debt increase. This in turn created large discrepancy in rising structural indebtedness relative to reduction of actual indebtedness. Eventually, structural and actual indebtedness converged, since the contribution of the CA primary balance drooped nearly zero value.

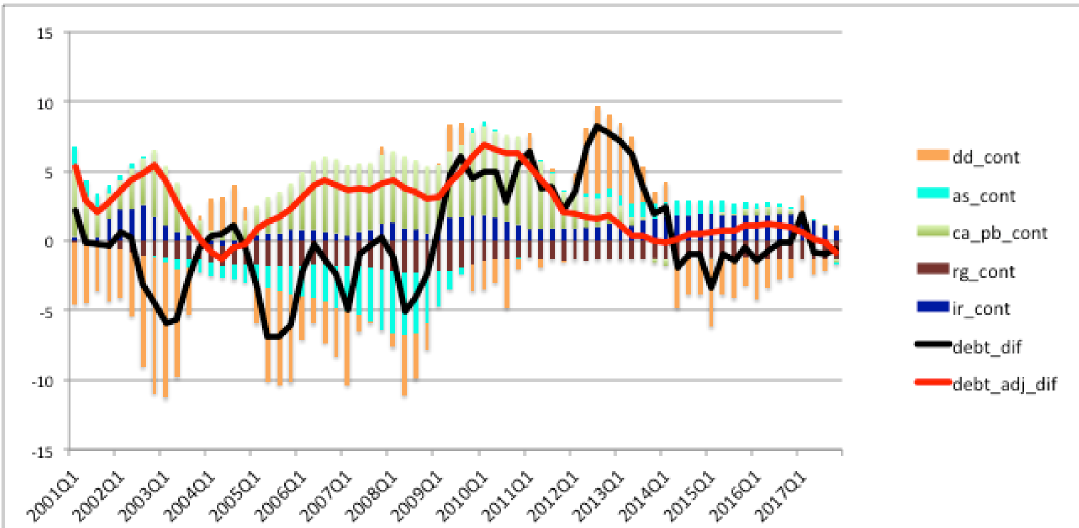


Figure 5.8g: Public debt growth decomposition - Slovak Republic
Source: *DS1, own calculation*

Slovenia (Figure 5.8h)

During the pre-crisis period, Slovenia experienced low volatility in public debt-to-GDP growth, with mutual offsetting of positive and negative debt growth contributions. Situation severely changed in the aftermath of the crisis, when growth of public debt exploded, being among the fastest rising debts in CEE 8. Until 2014, almost all debt determinants contributed to the rise of public debt, but in the last three years of period covered debt increments dropped and debt stabilized.

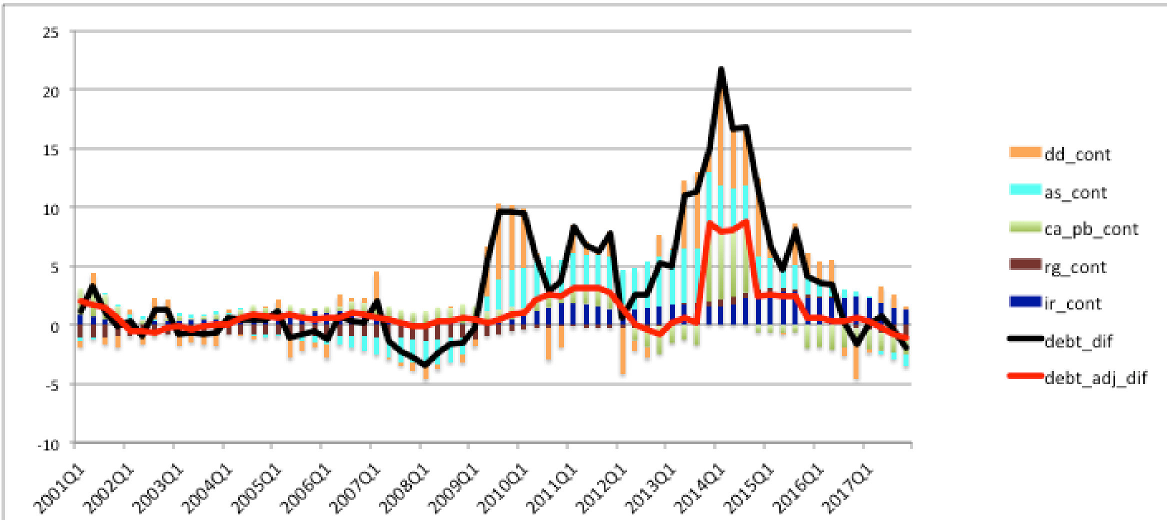


Figure 5.8h: Public debt growth decomposition – Slovenia
Source: *DS1, own calculation*

5.5 Econometric modeling of the public debt dynamics

In this section, I use linear regressions to assess whether the variations in EEC 8 public debt dynamics can be and to which extent explained by the macroeconomic variables theoretically assumed to be debt drivers. This question may appears trivial if the debt increments perfectly correspond to overall fiscal balances, but we saw in the previous section that automatic stabilizers and debt-deficit adjustment were among the dominant forces in public debt formation. The regression model specification is based on the DAE in relative terms. The generic representation of a panel regression model is given by

$$y_{it} = X_{it}\beta + \varepsilon_{it}; \quad i = 1, \dots, N; t = 1, \dots, T. \tag{5.2}$$

where y_{it} denotes the dependent variable for country *i* in the period *t*, X_{it} is the vector of explanatory variables, ε_{it} is a disturbance term, N is the number of countries and T is the number of time observations in the sample. A disturbance term typically comprises of time-invariant individual specific effect ν_i and "true" random error, i.e. white noise process u_{it}:

$$\varepsilon_{it} = \nu_i + u_{it}. \tag{5.3}$$

EEC 8 sample consists of 8 countries and covers $T = 68$ observations, except for Croatia and Serbia where $T = 56$ and $T = 49$, respectively. Such panel structure where T is considerably higher than N is also known as time series cross-section data (TSCS). Modeling of the TSCS datasets requires additional caution, as the issues of non-stationarity, autocorrelation, cross-sectional dependence and heteroscedasticity must be taken into account in the statistical inference. We already illustrate in previous section that some time series of non-fiscal and fiscal variables exhibit heteroscedasticity and cross-country correlation, so I discuss in details potential issues of panel econometric analysis when variables do not meet OLS requirements.

Batalgi et al. (2007) discuss different underlying data generating processes of the explanatory variables and the disturbance term. Assuming that X_{it} and u_{it} follow an AR(1) process

$$X_{it} = \theta X_{it-1} + e_{it}; \tag{5.4}$$

$$u_{it} = \rho u_{it-1} + \epsilon_{it}, \tag{5.5}$$

where e_{it} and ϵ_{it} are white noise processes. If y_{it} is first-order integrated process, Batalgi et al. (2007) distinguish the cases of panel cointegration model, where $\theta = 1$ and $|\rho| < 1$, and the panel spurious regression, where $\theta = 1$ and $\rho = 1$, and show that the efficiency of panel estimators can differ in those cases. Further, Hoechle (2007) provides an excellent summary of pros and cons of different panel estimators with respect to misspecifications of the classic OLS assumptions regarding the disturbance term. Under the assumption that ε_{it} follows the IID process $\varepsilon_{it} \sim IID(0, \sigma^2)$, the covariance matrix of the disturbances, $\Omega_{\varepsilon\varepsilon} = E[\varepsilon\varepsilon']$, will be diagonal block matrix

$$\Omega_{\varepsilon\varepsilon} = \begin{bmatrix} \sigma^2 I & \dots & 0 \\ \dots & \ddots & \dots \\ 0 & \dots & \sigma^2 I \end{bmatrix} \tag{5.6}$$

where $\sigma^2 I$ represents the covariance matrix of single unit disturbances. If we assume that disturbances are heteroscedastic, $\Omega_{\varepsilon\varepsilon}$ has the form

$$\Omega_{\varepsilon\varepsilon} = \begin{bmatrix} {\sigma_{11}}^2 I & \dots & 0 \\ \dots & \ddots & \dots \\ 0 & \dots & {\sigma_{NN}}^2 I \end{bmatrix}, \tag{5.7}$$

where ${\sigma_{ii}}^2$ denotes specific variance of given panel unit. By relaxing the assumption that disturbances are non autocorrelated within the units, $\Sigma_{\varepsilon\varepsilon}$ can be written as

$$\Omega_{\varepsilon\varepsilon} = \begin{bmatrix} {\sigma_{11}}^2 \Omega_{11} & \dots & 0 \\ \dots & \ddots & \dots \\ 0 & \dots & {\sigma_{NN}}^2 \Omega_{NN} \end{bmatrix}, \tag{5.8}$$

where Ω_{ii} specifies correlation structure of disturbances within the given unit. Further relaxation of the assumption that disturbances are not independent (non-correlated) across the units gives the most generic form of the $\Omega_{\varepsilon\varepsilon}$

$$\Omega_{\varepsilon\varepsilon} = \begin{bmatrix} {\sigma_{11}}^2 \Omega_{11} & \dots & \sigma_{1N} \quad \Omega_{1N} \\ \dots & \ddots & \dots \\ \sigma_{N1} \quad \Omega_{N1} & \dots & {\sigma_{NN}}^2 \Omega_{NN} \end{bmatrix}, \tag{5.9}$$

where matrices $\sigma_{ij}\Omega_{ij}$ specifies cross-sectional correlation of disturbances between two units. Literature provides various approaches to TSCS modeling in attempt to overcome violation of classic OLS assumption, which will be discussed further in this section.

Based on the DAE, I specified the following empirical model:

$$\Delta ind_t = \beta_0 + \beta_1 r_t + \beta_2 rg_t^p + \beta_3 \pi_t + \beta_4 \Delta rfx_t + \beta_4 capb_t^p + \gamma D_t + \varepsilon_{it}, \tag{5.10}$$

where Δind_t denotes the change in indicator of public indebtedness. On the RHS of the equation, the variables r_t, rg_t^p, π_t, Δrfx_t and $capb_t^p$ denote the implied interest rate, real growth of potential GDP, inflation rate (GDP deflator), real exchange rate depreciation, and the cyclically-adjusted primary balance scaled by potential GDP, respectively. The dummy variable D_t is equal to one in the period during and after the spillover of the global financial crisis (and European sovereign debt crisis), zero otherwise. In line with previous discussion, three feasible indicators of public indebtedness are used to specify debt dynamics as dependent variable:

- change in actual indebtedness, Δd_t;

- change in cyclically-adjusted indebtedness, computed as an actual debt increment corrected by automatic stabilizers, both scaled by potential GDP, $\Delta cad_t^p = \Delta d_t^p + as_t^p$;
- change in structural indebtedness, computed as the difference between change in cyclically-adjusted indebtedness and debt-deficit adjustments, both scaled by potential GDP, $\Delta sd_t^p = \Delta cad_t^p - dd_t^p$

In order to guard our analysis against the effects of possible TSCS data deficiencies, procedure of econometric analysis is applied in three steps. First, I handle stationarity issues to avoid the above-mentioned cases of cointegration and spurious regression. Subsequently, I examine properties of the disturbance term. Finally, I consider a variety of applicable estimators to provide the reliable estimation of the model parameters under the different assumptions on random disturbances ε_{it} discussed above.

5.5.1 Panel unit root tests

The panel unit root tests can be roughly grouped to "first generation" and "second generation" (Hossfeld, 2010). The tests of the first generation are derived from the generalization of the Augmented Dickey-Fuller (ADF), which is most commonly used unit root test in single time series analysis. The panel specification of the ADF equation (deterministic components like constant, trend or time dummies are neglected for simplicity) can be written as

$$\Delta y_{i,t} = \rho_i y_{i,t-1} + \sum_{p=1}^{P_i} \phi_{ip} \Delta y_{i,t-p} + \varepsilon_{it},\ i = 1, \dots, N; t = 1, \dots, T. \quad (5.11)$$

where ρ_i denotes the unit-specific AR(1) coefficient, while the disturbance terms are normally and independently distributed across units. The simplest case of the ADF panel unit-root tests is the Levin-Lin-Chu test (LLC), assuming the common unit root across individuals. Under this simplifying assumption, the LLC tests the null that $H_0: \rho_i = \rho = 0\ \forall i$, against the alternative $H_1: \rho_i = \rho < 0\ \forall i$. The Im-Pesaran-Shin test (IPS) allows the possibility of unit-specific common roots, and therefore to test the null that $H_0: \rho_i = 0\ \forall i$ against the alternative $H_1: \exists i \in \{1, \dots, N\}, \rho_i < 0$. It is computed as a group-mean of unit-specific t-statistics, so it does not require a strongly balanced panel. Yet, the IPS test still suffers from the restricting assumption on independency between panel units, particularly unrealistic in case of macroeconomic time series. A cross-sectional demeaning of the data improves the reliability of the first generation tests, but the unit-root tests of the second generation completely relaxes this assumption. The notable solution of this issue is the cross-sectional IPS test (CIPS), proposed by Pesaran (2007). Instead of the simple extension of the univariate ADF regression over units, he proposes a cross-sectional ADF regression (CADF), which adds lagged cross-sectional means of units $\bar{y}_t$ to control for a common factor

$$\Delta y_{i,t} = \rho_i y_{i,t-1} + \varphi_i \bar{y}_{t-1} + \psi_i \Delta \bar{y}_t + \varepsilon_{it},\ i = 1, \dots, N; t = 1, \dots, T. \quad (5.12)$$

The equation neglects the lagged differences of $y_{i,t}$ and $\bar{y}_t$ for simplicity. The testing procedure of the CIPS is the same as in case of the IPS test.

Following the unit root testing framework, I applied the LLC, the IPS and the CIPS tests to the set of variables included in the econometric specification of the model. I considered both cases of ADF deterministic terms: case of constant only, and case of trend and constant. Due to panel nature of analysis, I neglected the structural breaks in the individual time series and discuss that issue in the next chapter in which individual time series are analyzed. The LLC test requires balanced panel data, so I adjusted scope of sample for each variable to make it strongly balanced. In case of the LLC and the IPS tests, I demeaned the data cross-section to mitigate impact of correlated disturbances across the units. Results of the unit root testing are presented in the Table 5.8. Column “Sample” refers to a country whereby lack of observations on certain variable reduces coverage of strongly balanced data needed for LLC testing, and respective cut-off quarter.

Table 5.8: Panel unit root tests

Variable	Test type	Constant	Constant and trend	Sample
Δd_t	LLC	-2.1462**	-0.9612	2005 Q3 (SRB)
	IPS	-2.6225***	-2.7980***	full
	CIPS	-3.653***	-2.545***	full
Δcad_t^p	LLC	-2.5579***	-1.3811*	2005 Q3 (SRB)
	IPS	-3.4919***	-4.5177***	full
	CIPS	-4.020***	-3.230***	full
Δsd_t^p	LLC	-3.0512***	-0.9317	2005 Q3 (SRB)
	IPS	-1.1982	-2.4934***	full
	CIPS	-0.850	-1.622**	full
r_t	LLC	-1.7291**	-2.0138**	2005 Q4 (SRB)
	IPS	-5.2696***	-4.3894***	full
	CIPS	-1.732**	-0.746	full
rg_t^p	LLC	-0.7167	-0.4406	2002 Q2 (HRV)
	IPS	-4.2431***	-2.3482***	full
	CIPS	-3.298***	-3.114***	full
π_t	LLC	-4.5301***	-6.1750***	2003 Q1 (SRB)
	IPS	-3.9858***	-3.1536****	full
	CIPS	-4.979***	-4.666***	full
Δrfx_t	LLC	-8.8835***	-8.8678***	2003 Q1 (SRB)
	IPS	-5.1387***	-5.2869***	full
	CIPS	-7.943***	-6.738***	full
$capb_t^p$	LLC	-1.3700*	-1.7345**	2005 Q4 (SRB)
	IPS	-1.0023	-1.5874*	full
	CIPS	-1.360*	-2.581***	full

Note: Null hypothesis: Panels are non-stationary; IPS and CIPS tests based on ADF and CADF group-mean t-test statistics, respectively.
Levels of significance: * p<0.1, ** p<0.05, *** p<0.01

Source: *own calculations*

The results of unit roots testing varies across variables. In case of inflation and real exchange rate depreciation, all variations of applied tests uniformly indicate stationarity of time series at 0.01 significance. For other variables majority of tests applied also indicate stationarity for at least 0.05 significance, with Δsd_t^p being the only case where results are mixed. Altogether, there is no indication of major rejection of stationarity in case of some variable, so I disregard the possibilities of cointegration and spurious regression as a matter of concern.

5.5.2 Model estimation

Traditional OLS-based panel estimators like Pooled OLS (POLS) or Fixed Effects OLS (FE OLS) estimators do not take into account possible violations of IID assumption of disturbance terms. Yet, various methods are proposed to compute consistent standard errors, like Huber-White errors robust to heteroscedasticity (Huber, 1967; White, 1980) or Rogers clustered standard errors robust to autocorrelation (Rogers, 1993), which work fine as long as disturbances are independent across units. The latter issue was alleviated by the Feasible Generalized Least Squares method (FGLS) proposed by Kmenta (1986), Beck & Katz (1995) panel corrected standard errors (PCSE) based on Prais –Winsten GLS estimator, or Driscoll & Kraay (1998) correction of OLS standard errors. The other possible source of estimation inefficiency in macroeconomic panels is a presence of endogeneity, i.e. correlation of disturbances with explanatory variables, typically caused by either unobserved heterogeneity or reverse causality. The first issue can be easily overcome by time demeaning or differentiating. If endogeneity comes from reverse causality, estimators based on Instrumental Variables (IV) approach turns to be more efficient than OLS/GLS based estimators in case that instruments are relevant and valid. The Table 3.11 summarizes discussed pros and cons of the selected panel data estimators.

Table 5.9: Panel data estimators pros and cons

	Handle endogeneity due to…		Standard errors estimates robust to disturbances being…		
Estimator type	Unobserved heterogeneity	Reserve causality	Hetero scedastic	Auto correlated	Cross-sectionally dependent
POLS	no	no	yes	yes	no
FE OLS	yes	no	yes	yes	no
FGLS	no	no	yes	AR(1)	contemporaneous
2SLS IV	yes	yes	no	no	no
DK OLS	yes	no	yes	MA(q)	yes
PCSE GLS	no	no	yes	yes	yes

Source: *author, based on Hoechle (2007)*

As the sample consists of macroeconomic TSCS data, it is reasonably to expect that each of the disturbance and endogeneity issues may affect the efficiency of estimation. To handle the issues of OLS violations related to disturbance term, I use residuals obtained by the OLS estimation of equation (5.2) and apply the following tests:

- **Autocorrelation issue.** Wooldridge test for autocorrelation in panel data, proposed by Wooldridge (2002), is used to test H0: “there is no first-order autocorrelation of residuals”. Under the null, test statistic will follow F distribution.
- **Heteroscedasticity issue.** Modified Wald test for groupwise heteroscedasticity in fixed effect regression model, proposed by Greene (2000), is used to test H0: “variance of residuals is homoscedastic”. Under the null, test statistic will follow Chi-squared distribution.
- **Cross-sectional dependency issue.** Breusch–Pagan LM test (1980), valid for small N and large T, is used to test H0: “there is no cross-sectional dependency of residuals”. Under the null, test statistic will follow Chi-squared distribution.

All of these tests are robust to the presence of unobserved hetegoregeneity ν_i, specified in composite representation of the disturbance term in (5.3). Tests are applied to all three versions of the model with respect to choice of dependent variable. The results of the testing are shown in the Table 5.10.

Table 5.10: Test of OLS violations

Test / Dependent variable	Δd_t	Δcad_t^p	Δsd_t^p
Wooldridge test for autocorrelation	15.711***	15.050***	285.164***
Wald test for heteroscedasticity	144.51***	182.67***	737.22***
Breusch–Pagan LM test (1980) of independence	82.241***	67.523***	426.322***

Levels of significance: * p<0.1, ** p<0.05, *** p<0.01

Source: *own calculations*

In case of all three versions of the dependent variable, test statistics clearly reject OLS assumptions on disturbance term. Therefore, I estimate the model using 6 different estimators that reads in the Table 5.9, taking into account disturbance-related issues. In particular, Roger’s clustered errors correction is applied to POLS, FE OLS and 2SLS estimation to obtain standard errors robust to heteroscedasticity and autocorrelation. The estimation is conducted using Stata 13.0 software package. The estimation results for each version of dependent variable are presented in three subsequent tables denoted as 5.11a – 5.11c, respectively.

Table 5.11a: Estimation results for change in actual indebtedness as a dependent variable

Δd_t	Pooled OLS	FE OLS	2SLS IV	FGLS	DK OLS	PCSE GLS
crisis	-5.2192***	-5.9890***	-6.3482***	-2.6074***	-5.9890***	-3.0592***
	(1.1908)	(1.1537)	(0.9131)	(0.5835)	(0.7383)	(0.6792)
r_t	0.7516**	0.9280**	0.8763**	0.7311***	0.9280***	0.9222***
	(0.2402)	(0.3425)	(0.4367)	(0.1142)	(0.2009)	(0.1323)
rg_t^p	-0.4575***	-0.2289	-0.3860**	-0.2267	-0.2289	-0.2589*
	(0.1146)	(0.1412)	(0.1631)	(0.1485)	(0.1440)	(0.1490)
π_t	-0.1650	-0.1882	-0.1103	-0.2688***	-0.1882*	-0.2811***
	(0.0894)	(0.1106)	(0.1520)	(0.0615)	(0.0950)	(0.0701)
Δrfx_t	-0.0988	-0.0685	-0.0594	-0.0838***	-0.0685	-0.1294***
	(0.0632)	(0.0742)	(0.0710)	(0.0270)	(0.0443)	(0.0319)
$capb_t^p$	-0.9075***	-0.9243***	-1.2411***	-0.4801***	-0.9243***	-0.4969***
	(0.1415)	(0.1774)	(0.2683)	(0.0886)	(0.1313)	(0.0990)
const	0.0509	-1.1882		-0.6797	-1.1882	-1.5918*
	(1.1454)	(1.2697)		(0.7326)	(1.0599)	(0.8671)
No. of Obs.	513.00	513.00	507.00	513.00	513.00	513.00
R-Squared	0.51	0.55	0.54			0.21

Note: Standard errors in parenthesis

Levels of significance: * p<0.1, ** p<0.05, *** p<0.01

Source: *own calculations*

Table 5.11b: Estimation results for change in cyclically-adjusted indebtedness as a dependent variable

Δcad_t^p	Pooled OLS	FE OLS	2SLS IV	FGLS	DK OLS	PCSE GLS
crisis	-3.8686***	-4.3687***	-4.5218***	-1.8715***	-4.3687***	-2.0752***
	(1.0683)	(1.0984)	(1.0048)	(0.5226)	(0.7184)	(0.5329)
r_t	0.6946***	0.8057**	0.8792***	0.6806***	0.8057***	0.8332***
	(0.1848)	(0.3086)	(0.3366)	(0.1041)	(0.1753)	(0.1183)
rg_t^p	-0.7209***	-0.5606***	-0.5384***	-0.5057***	-0.5606***	-0.5933***
	(0.1466)	(0.1519)	(0.1335)	(0.1285)	(0.1376)	(0.1253)
π_t	-0.1679**	-0.1903	-0.1841	-0.2555***	-0.1903**	-0.2679***
	(0.0675)	(0.1131)	(0.1228)	(0.0548)	(0.0740)	(0.0609)
Δrfx_t	-0.1066	-0.0818	-0.0847	-0.0965***	-0.0818*	-0.1393***
	(0.0639)	(0.0738)	(0.0674)	(0.0254)	(0.0433)	(0.0286)
$capb_t^p$	-0.8124***	-0.8166***	-0.8122***	-0.4857***	-0.8166***	-0.5192***
	(0.1203)	(0.1519)	(0.1700)	(0.0796)	(0.1091)	(0.0871)
const	0.6371	-0.1489		0.1883	-0.1489	-0.5354
	(0.9083)	(1.1645)		(0.6220)	(0.8859)	(0.6809)
No. of Obs.	513.00	513.00	507.00	513.00	513.00	513.00
R-Squared	0.55	0.57	0.57			0.25

Note: Standard errors in parenthesis

Levels of significance: * p<0.1, ** p<0.05, *** p<0.01

Source: *own calculations*

Table 5.11c: Estimation results for change in structural indebtedness as a dependent variable

Δsd_t^p	Pooled OLS	FE OLS	2SLS IV	FGLS	DK OLS	PCSE GLS
crisis	-1.9018**	-1.9625**	-2.0504***	-0.6398***	-1.9625***	-0.7801***
	(0.7191)	(0.7404)	(0.6395)	(0.1016)	(0.2268)	(0.1645)
r_t	0.5627**	0.5662*	0.5831**	0.3363***	0.5662***	0.3060***
	(0.1742)	(0.2848)	(0.2929)	(0.0276)	(0.1201)	(0.0278)
rg_t^p	-0.6586***	-0.6029***	-0.6178***	-0.6678***	-0.6029***	-0.7121***
	(0.1041)	(0.1032)	(0.1048)	(0.0321)	(0.0350)	(0.0349)
π_t	-0.2895***	-0.3039**	-0.2921**	-0.2963***	-0.3039***	-0.2881***
	(0.0671)	(0.1229)	(0.1267)	(0.0156)	(0.0572)	(0.0161)
Δrfx_t	-0.0409*	-0.0299	-0.0285	-0.0053	-0.0299	-0.0056
	(0.0176)	(0.0208)	(0.0177)	(0.0045)	(0.0255)	(0.0054)
$capb_t^p$	-0.9226***	-0.9040***	-0.9361***	-0.9789***	-0.9040***	-0.9729***
	(0.0806)	(0.0804)	(0.0970)	(0.0154)	(0.0337)	(0.0151)
const	0.5844	0.5066		1.0042***	0.5066	1.3271***
	(0.5326)	(0.7670)		(0.2297)	(0.4535)	(0.3129)
No. of Obs.	513.00	513.00	507.00	513.00	513.00	513.00
R-Squared	0.80	0.83	0.83			0.91

Note: Standard errors in parenthesis

Levels of significance: * p<0.1, ** p<0.05, *** p<0.01

Source: *own calculations*

Before commenting results of estimation, it is also important to clarify 2SLS IV estimator, being the only one that handles issue of potential endogeneity of the CA primary balance as a regressor in the model. The issue of endogeneity is stemming from the specification of the fiscal reaction function at (3.10): since autocorrelation of the change in indebtedness is very likely, there will be reverse contemporaneous causality between primary balance and change in debt. In order to address this issue, primary balance is instrumentalized by the sample averages of the potential GDP growth and the first lag of cyclically-adjusted debt, as well as by the sample average of the first lag of CA primary balance. Following the specification of the FRF, such instruments should be relevant explanatory variables of CA primary balance, but also uncorrelated to random error. This is checked by the following post-estimation test:

- **Kleibergen-Paap rk Wald F test of underidentification.** The null hypothesis is that number of instruments is less than number of endogenous variables. Under the null, test statistics will follow F distribution.

- **Kleibergen-Paap rk Wald F test of weak identification.** This test basically does not have null hypothesis, but rather figures out whether IV estimation is inferior to OLS estimation, Inferiority of the IV estimation indicates that instruments are weak, i.e. not relevant enough to instrument endogenous variable. There are two ways in which this statistics can be interpreted:
    1. inference based on rule of tumb (Staiger & Stock, 1997); if value of F statistics is less than 10, instruments are regarded as weak;
    2. inference based on Stock-Yogo critical values (Stock & Yogo, 2005); comparison of F statistics with tabulated Stock-Yogo critical values gives an assessment of IV estimator maximal bias relative to OLS, or in other version assessment of the maximal size of F test (probability that correct null is rejected);
- **Hansen J test of overindentification.** The null hypothesis is that instruments are valid, i.e. not correlated with model random errors. Under the null, test statistics will follow Chi-squared distribution.

The results of the IV post-estimation tests are given in the Table 5.12. As Kleibergen-Paap rk Wald F tests of under- and weak identification do not depend on dependent variable, test statistics is common for the all three versions of the model. Since underidentification null is rejected at 1% significance and maximal bias is 5%, instruments can be regarded as relevant. In addition, Hansen J test does not reject null that instruments are valid.

Table 5.12: 2SLS IV Post-estimation test

Test / Dependent variable	Δd_t	Δcad_t^p	Δsd_t^p
Kleibergen-Paap rk Wald F test of underidentification	6.759***		
Kleibergen-Paap rk Wald F test of weak identification (relative bias to OLS)	5% maximal bias		
Hansen J statistics	1.952	0.309	3.304

Levels of significance: * p<0.1, ** p<0.05, *** p<0.01

Source: *own calculations*

When estimation results of all three versions of the model are compared, several important findings can be noted. In cases when dependent variables are actual and CA debt increments, available estimated values of R-squared are modest and even low for PCSE. On the other side, when dependent variable is change in structural indebtedness, R-squared sharply increases, especially in case of PCSE estimator. This indirectly indicates that debt-deficit adjustments are very significant explanatory factor of the debt increment variations; once when it is removed, explanatory power of the model substantially increased.

When particular impact of debt determinants is considered in case of change in actual indebtedness as a dependent variable, implied interest rate and CA primary balance appears as the only two regressors which significance is robust to all estimators applied. Results on significance of the other determinants are mixed and do not indicate robust power in explanation of actual debt dynamics variation. Situation changes when cyclically-adjusted debt increment is dependent variable. Potential GDP growth gained robust significance, when temporarily swings of public debt due to primary balance and output cyclicality are removed, which is in line with expectations.

When the change in structural indebtedness appears as a dependent variable, inflation also became robustly significant debt driver. The results indicate statistically significant negative response of debt changes in the EEC to higher inflation. Interpreting this response is not straightforward though. On the GDP side, higher inflation should lead to higher value of nominal GDP in denominator and therefore reduce the debt-to-GDP ratio. On the debt servicing cost side, higher inflation should lead to higher nominal interest rates and depreciation of nominal exchange rates due to the PPP principle and therefore should increase the debt-to-GDP ratio. Which of the two effects prevails seem to be ultimately an empirical question, but negative estimated value of the regression coefficient indicates that in case of EEC 8 denominating effect prevailed.

The dynamics of the public debt seems to be very sensitive to interest rates. It should be noted that the implied interest rate used in this analysis reflects both changes in market interest rates and changes in the nominal exchange rate for countries with floating exchange rate regimes. The high sensitivity of public debt to interest rate should not be confused with relatively lower contribution of real interest rate differential to debt increment, illustrated in debt decomposition exercise. Instead, interest rates, apart from the rear situations when they are negative, covariate in the same direction as public debt.

Eventually, size and significance of estimated impact of real appreciation is unstable, but direction is clearly negative and its significance was confirmed in several cases of estimation. This is a bit tricky for explanations. Real exchange rate appreciation is typically associated with worsening of international competitiveness and rising current deficits, as it was a case in EEC in general. According to the principle of twin deficits, real exchange rate should be also associated with rising fiscal deficits, and consequently with growing debt. Yet, in case of economic cyclicality driven by foreign capital inflows, so-called situation of “twin divergence” can occur; automatic increase in government revenue reduces deficits and public debt, along with real exchange rate appreciation and worsening of current deficits, and vice versa. Which is the most likely reason of observed negative association between real exchange rate appreciation and public debt dynamic.

Taking all findings into account, it can be claimed that both H1 and H2 hypotheses are proved. Explanatory power of the model is solid and increases when structural measure of indebtedness is used, indicating existence of significant correlation between change of debt dynamics and debt determinants. Descriptive analysis of debt decomposition imposes that debt-deficit adjustments and CA primary balance as the fiscal variables are the most important contributors of public debt dynamics. In addition, when the change in structural indebtedness is used as a dependent variable in the model, debt dynamics is most sensitive to the variations in CA primary balance since the impact of interest rate considerably falls relative to cases of actual and CA debt increments being dependent variable. Therefore, second hypothesis that dynamic and cost of public debt are more sensitive to fiscal than non-fiscal driver is claimed to be proved.

6 FISCAL SUSTAINABILITY ASSESSMENT OF SERBIA AND PEER COUNTRIES

Literature review revealed that the most important drawback of the academic literature on the public debt sustainability and cost-risk analysis in general is lack of the out-of-sample performance. While the international organizations working according to the standardized DSA and CaR methodologies have started to pay attention on forecasting reliability in the recent years, the academic literature mostly approached to this topics *ad hoc* and *ex ante*, without check out how the forward-looking empirical results stemming from the proposed models and methodologies feet actual data.

With this in mind, empirical strategy in this work has an unusual approach. Instead of producing empirical research on future debt sustainability beyond 2019 (which is basically task of international organizations and national governments), empirical work in this chapters employs use methods of forecasting of the debt determinants and respective debt dynamics to discuss and assess quality of its out-of-sample performance. Therefore, empirical strategy is set to simulate kind of "experiment", in which analyst back in time assesses mid-term debt sustainability using data and methodologies available at that moment, and then compare the results of such forward-looking analysis with actual realizations of debt and debt determinants' dynamics, but also with other benchmark forecasts. Since scope of the DS1 database which is used in empirical analysis in the previous chapter cover data up to 2017, and that usual time range of mid-term period is 3-5 years, 2012 is set to be base year, so that forecasts starts in 2013.

6.1 Forecasts of the public debt determinants

From the theoretical point of view, government expenditure together with money supply are typically perceived as the most exogenous macroeconomic variables, being under control of the fiscal and monetary authorities. Following the standard macroeconomic concepts such as IS-LM-BoP or AS-AD frameworks, economic activity, interest rate, exchange rates and inflation are considered as variables that endogenously adjust to achieve macroeconomic equilibrium. On the other side, fiscal authorities in small open economies in practice usually apply forecasting procedure other way around: first, non-fiscal variables are predicted (or assumed), and then decisions on fiscal targets are made. The rational for such approach is very clear: in one small open economy, domestic market variables are strongly affected by their counterparts on international markets. If domestic market variables are not credibly adjusted to international swings, this will create large market distortions and unsustainable external imbalances, distracting stable economic growth at least in the long run. Thus, baseline scenario in fiscal strategy reflects government expectations about revenues and expenditures dynamics, based on a set of assumptions about envisaged dynamics non-fiscal variables.

This brief introductory discussion points out the main forecasting issues in practice: how to make joint forecast of the macroeconomic variables that will maintain contemporaneous and intertemporal consistency of macroeconomic relations and balances? To illustrate this point lets assume a simple example that government forecasts the following changes in macroeconomic variables in the 10-year period:

- real interest rate: does not change
- nominal interest rate: 2% – 6%
- inflation rate: 2% – 4%
- interest payment to GDP: does not change
- real growth: does not change

As first, it can be noticed that there is contemporaneous inconsistency between forecasts of nominal interest rate and inflation. Since real interest rate does not change, the Fisher equation imposes that increase in nominal interest rate will coincide with rise in inflation rate. Further, if real growth rate does not change, GDP will grow at inflation rate, while interest payments will grow at nominal interest rate; consequently, growth of interest payments at higher rate than GDP growth over 10-year period will increase its share in GDP, making the forecast of constant share of interest payment inconsistent in intertemporal terms.

Since the long term forecasting requires large equilibrium macroeconomic model to maintain intertemporal consistency, focus on short to mid run forecasting brings about important benefit. If mid run deviations from equilibrium are allowed, it is reasonable to arbitrary declare some variables as endogenous and model their forecasts separately, taking projections of other interrelated variables as exogenous inputs. For instance, non-fiscal market variables can be forecasted separately of forecasting fiscal variables, assuming that in the mid run changes in interest and exchange rate will not affect government fiscal decisions. Additionally, such approach is in line with mid-term budgeting practices of the fiscal authorities, in which forecast are updated each year to accommodate recent economic developments.

In this section I elaborate two approaches of the debt determinants forecasting:

1. Deterministic approach to joint modeling of market determinants of debt (interest rate and exchange rate), based on common economic theory presented in subsection 2.3.2, independently from inflation rate, real GDP growth and primary balance. Primary balance and inflation are regarded as the fully exogenous variables in line with reasoning that government and national bank will stick to mid-term fiscal and monetary targets. In addition, it is assumed that real GDP growth is also exogenous variable predetermined by the production capacities of economy, and not affected in the mid run by non-fiscal variables. Eventually, it is assumed that fiscal and real variables does not have impact on market variables, while forecast of inflation enters into modeling framework as an exogenous input.

2. Stochastic approach to joint modeling of all debt determinants, based on econometric modeling of historical data. In this approach, all variables are regarded as endogenous.

6.1.1 Deterministic approach to forecasting of debt market determinants

Deterministic approach to forecasting of the interest rate basically follows the operationalization of the equation (2.39), which in nominal terms reads

$$i_{i,t} = z_t + rpm_i \tag{6.1}$$

where z_t is nominal spot rate, and rpm_i is risk premium for debt instrument i which is assumed to be time-invariant. In reality, value of the interest rate does not depend only on time, but also on maturity of the respective instrument. If index i of the instrument is neglected for a sake of simplicity and maturity T of the instrument is added into equation, it can be written as

$$i_{T;t} = z_{T:t} + rpm_T \tag{6.2}$$

This relation can be rewritten in forward-looking form as

$$i_{\tau,T;t} = z_{\tau,T;t} + rpm_{\tau,T} \tag{6.3}$$

where $i_{\tau,T;t}$ is future interest rate of the debt instrument of maturity $T-\tau$ that will be issued at $t+\tau$, while $z_{\tau,T;t}$ is a future spot rate of maturity $T-\tau$ that will be realized at $t+\tau$. Mechanics of the future spot interest rates projections is derived from the theoretical concept known as expectations hypothesis (EH), that represents basic and the most popular model explaining interest rate term structure. The term structure of interest rates, defined as the mapping of risk-free interest rates with respect to their maturities, empirically corresponds to the equation:

$$\left(1+z_{T;t}\right)=\left[\left(1+z_{1;t}\right)\left(1+f_{1,2;t}\right)\ldots\left(1+f_{T-1,T;t}\right)\right]^{1/T} \quad (6.4)$$

where $f_{T-1,T;t}$ is interpreted as a short-term forward interest rate of the risk-free bond issued at time *T-1*, falling due at *T*, which is known at time *t*. Generally speaking, the EH states that term structure of interest rates at a given time reflects the market expectations of future spot rates, based on the assumption that risk-free bonds of different maturities are perfect substitutes for investors. The EH mechanics can be mathematically expressed as

$$\left(1+z_{T;t}\right)=\left(1+z_{1;t}\right)E_t\left[\left(1+z_{1;t+1}\right)\ldots\left(1+z_{1;T}\right)\right]^{1/T} \quad (6.5)$$

which corresponds to the reasoning that yield on *T*-period bond is equal to expected return from rolling over one-period bonds for *T* periods. Under the assumption that short-term forward rates are reliable forecasts of the future spot rates, this relation can be generalized as $E_t\left[z_{\tau,T;t}\right]=f_{\tau,T;t}$, where t is a referent period, $f_{\tau,T;t}$ is forward interest rate on the debt instrument issued in τ periods after t and falls due at T. For instance, if *t*=2017, $\tau=2$, and *T*=5, the best forecast in 2017 of the 3-year future spot rate, that will be realized in 2019, is forward rate $f_{2,5;2017}$ derived from yield curve known in 2017. The forward rate are derived from the yield using generalized formula:

$$f_{\tau,T;t}=\left(\frac{\left(1+z_{T;t}\right)^{T-t}}{\left(1+z_{T-\tau;t}\right)^{\tau-t}}\right)^{\frac{1}{T-\tau}}-1. \quad (6.6)$$

In regard to the previous example, this equation tells that forward rate $f_{2,5;2017}$ will be derived from yield curve using relationship between spot rates of the maturities T and $T-\tau$. Once when future spot rates are forecasted, estimated risk premium for the particular debt instrument can be added in order to get full forecast of the future interest rate $i_{\tau,T;i,t}$.

Application of this approach in practice is quite straightforward in the advanced economies with developed financial markets, where full scope yield curve and respective risk premiums can be derived using market yields. On the other side, in emerging economies with shallow financial markets, lack of long-term bonds in domestic currency shrinks the longevity of respective yield curve, whilst frequency of trading is insufficient to assess full scope of risk premiums $rpm_{T;i}$ with respect to debt instruments and maturities.

Here I present example of simple framework for forecasting interest rate on RSD and EUR denominated Serbian T-bonds. The example is illustrated based on the referent period April 2019, which is regarded as starting time point *t*=0. The first step is forecast of the EUR future spot rates derived from ECB yield curve computed using rates of highest-graded T-bonds (available at ECB website), presented in the Figure 6.1.

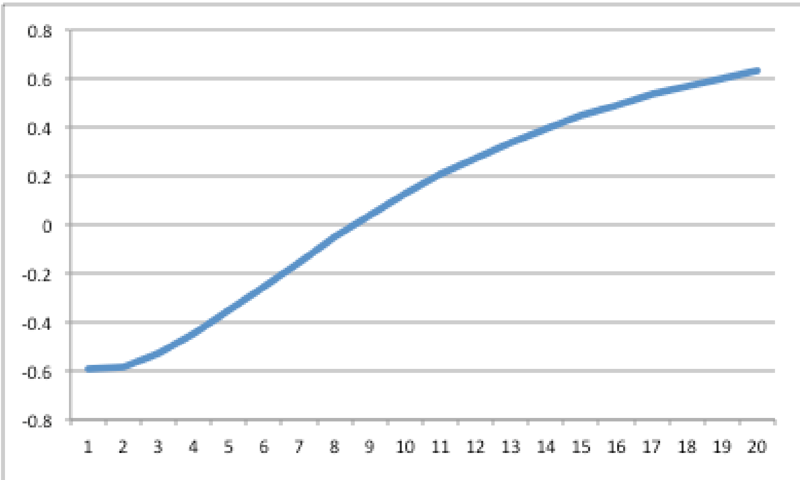


Figure 6.1: EUR yield curve up to 20 years maturity, April 2019
Source: *ECB*

The forward interest rates up to 10-year maturity for the forecasting period of 8 years ahead is computed using formula 6.6 and presented in the Table 6.1.

Table 6.1: EUR Forward rates based on EUR yield curve in April 2019

Maturity $T-\tau$	τ	1	2	3	4	5
	τ in years	2020	2021	2022	2023	2024
	$z_{T;0}$	$f_{1,T;0}$	$f_{2,T;0}$	$f_{3,T;0}$	$f_{4,T;0}$	$f_{5,T;0}$
1	-0.59%	-0.58%	-0.43%	-0.21%	0.03%	0.26%
2	-0.58%	-0.50%	-0.32%	-0.09%	0.15%	0.37%
3	-0.53%	-0.40%	-0.20%	0.03%	0.25%	0.46%
4	-0.45%	-0.30%	-0.09%	0.14%	0.35%	0.54%
5	-0.35%	-0.18%	0.03%	0.24%	0.44%	0.61%
6	-0.25%	-0.08%	0.13%	0.33%	0.52%	0.67%
7	-0.15%	0.03%	0.22%	0.41%	0.58%	0.73%
8	-0.05%	0.12%	0.31%	0.48%	0.64%	0.77%
9	0.04%	0.21%	0.38%	0.55%	0.69%	0.81%
10	0.13%	0.29%	0.45%	0.60%	0.74%	0.85%

Source: *own calculations*

EUR forward rates are regarded as a forecast of the future EUR spot rates $z_{\tau,T;t}^{EUR}$. In an ideal case, similar procedure would be repeated to obtain RSD forward rates using RSD yield curve. Yet, since RSD yield curve is not available, it is assumed that EUR yield curve is a proxy of the RSD yield curve in real terms, following description of real spot rates in (2.39). RSD future rates are then computed as a sum of τ-period ahead RSD inflation forecast π_{τ}^{RSD} (assumed to be exogenous[35]) and relevant EUR future spot rate, $z_{\tau,T;t}^{RSD} = z_{\tau,T;t}^{EUR} + \pi_{\tau}^{RSD}$. Consequently, two types of risk premiums are needed to forecast future interest rates on Serbian T-bonds:

1. risk premium on EUR denominated bonds, being a difference between realized trading yields of EUR T-bonds and forecasted EUR future rates,

$$rpm_{\tau,T}^{EUR} = i_{\tau,T;0}^{EUR} - f_{\tau,T;0}^{EUR}\ ; \qquad (6.7)$$

2. risk premium on RSD denominated bonds, being a difference between realized trading yields of RSD T-bonds and RSD forecasted RSD future rates,

$$rpm_{\tau,T}^{RSD} = i_{\tau,T;0}^{RSD} - f_{\tau,T;0}^{RSD}. \qquad (6.8)$$

As being said, due to data deficiency it is not possible to cover estimate of risk premiums for full range of maturities up to 10 years, nor get the fresh data on traded yields in base period April 2019. Therefore, taking into account that interest rates and inflation were stable in 2017 and 2018, yields at which T-bonds are traded at primary auctions from last two years are used to estimate risk premiums. T-bond issuance in 2017-2018 are summarized in the Table 6.2.

Table 6.2: Serbian T-Bonds issued in 2017-2018

Maturity	**EUR denominated T-Bonds**				**RSD denominated T-Bonds**			
	ISIN	Issue date	Due date	Market yield	ISIN	Issue date	Due date	Market yield
1	RSMFRSD66665	5/21/18	5/29/19	0.45%	*N/A*	*N/A*	*N/A*	*N/A*
2	RSMFRSD96779	3/22/18	3/26/20	1.00%	RSMFRSD60304	1/10/17	1/12/19	3.50%
3	RSMFRSD41981	4/20/18	4/24/21	1.25%	*N/A*	*N/A*	*N/A*	*N/A*
4	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
5	RSMFRSD36601	4/16/18	4/18/23	1.75%	RSMFRSD76292	1/23/18	1/25/23	4.50%
6	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*

[35] Forecasts of inflation rate are retrieved from the World Economic Outlook database of the IMF

7	RSMFRSD59421	6/11/18	6/13/25	2.50%	*N/A*	*N/A*	*N/A*	*N/A*
8	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
9	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
10	RSMFRSD20605	3/26/18	3/28/28	3.50%	RSMFRSD55940	2/6/18	2/8/28	5.88%

Source: *PDA data*

Insufficiency of data on yields is particularly visible in case of RSD T-bonds, where only three maturities are available. Applying the equations (6.7) and (6.8) on the available maturities for $\tau = 0$, $rpm_{0,T}^{EUR} = i_{0,T;0}^{EUR} - z_{T;0}^{EUR}$ and $rpm_{0,T}^{RSD} = i_{0,T;0}^{RSD} - z_{T;0}^{RSD}$, risk premiums are calibrated for the available EUR and RSD maturities, while the risk premiums for the missing maturities are simply interpolated. The calibrated risk premiums are given in the Figure 6.2.

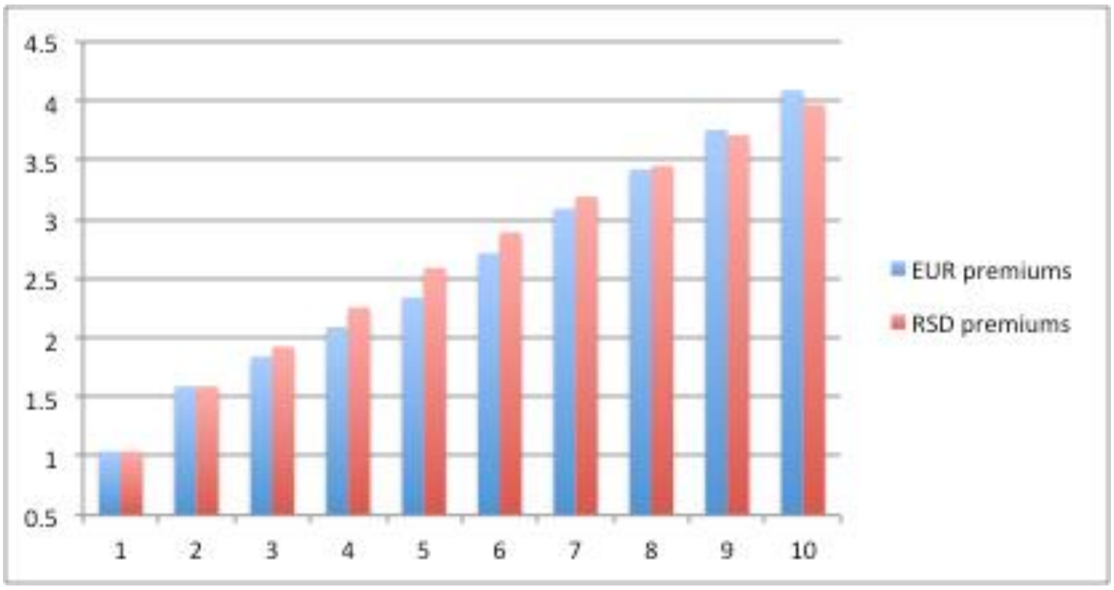


Figure 6.2: Calibrated risk premiums on EUR and RSD T-bills
Source: *own calculations*

Eventually, calibrated risk premiums by current spot rates ($\tau = 0$) are used to project full range of interest rates for $\tau = 1, \dots, 5$. The projections of the EUR and RSD interest rates are presented in tables 6.3a and 6.3b. As can be noticed by comparison of tables 6.2b and 6.3b with table 6.2, modeled current interest rates in the column 2019 fits actual yields at which T-bonds were traded.

Table 6.3a: Forecasted interest rates on future issuance of EUR denominated T-bonds, April 2019

Maturity/year of issuance	2019	2020	2021	2022	2023	2024
1	0.45%	0.46%	0.61%	0.83%	1.07%	1.30%
2	1.00%	1.01%	1.16%	1.38%	1.62%	1.85%
3	1.25%	1.26%	1.41%	1.63%	1.87%	2.10%
4	1.50%	1.51%	1.66%	1.88%	2.12%	2.35%
5	1.75%	1.76%	1.91%	2.13%	2.37%	2.60%
6	2.12%	2.14%	2.29%	2.51%	2.75%	2.98%
7	2.50%	2.51%	2.66%	2.88%	3.12%	3.35%
8	2.83%	2.85%	3.00%	3.21%	3.45%	3.69%
9	3.16%	3.18%	3.33%	3.55%	3.79%	4.02%
10	3.50%	3.51%	3.66%	3.88%	4.12%	4.35%

Source: *own calculations*

Table 6.3b: Forecasted interest rates on future issuance of RSD denominated T-bonds, April 2019

Maturity/year of issuance	2019	2020	2021	2022	2023	2024
1	2.95%	2.96%	3.61%	3.83%	4.07%	4.30%
2	3.50%	3.51%	4.16%	4.38%	4.62%	4.85%
3	3.83%	3.85%	4.50%	4.71%	4.95%	5.19%
4	4.16%	4.18%	4.83%	5.05%	5.29%	5.52%
5	4.50%	4.51%	5.16%	5.38%	5.62%	5.85%
6	4.80%	4.82%	5.46%	5.68%	5.92%	6.15%
7	5.10%	5.12%	5.76%	5.98%	6.22%	6.46%
8	5.36%	5.38%	6.02%	6.24%	6.48%	6.71%
9	5.62%	5.64%	6.28%	6.50%	6.74%	6.97%
10	5.88%	5.89%	6.54%	6.76%	7.00%	7.23%

Source: *own calculations*

Forecast of the exchange rate is stemming from the operationalization of the previously discussed concepts of Uncovered Interest Rate Parity (UIP). Following the equation (2.48), forward-looking application of the UIP concept requires prior knowledge on short-term interest rates to estimate expected depreciation of exchange rate one period ahead. This equation can be generalized for any maturity τ as

$$\left(1 + z^{d}_{\tau;t}\right) = \left(1 + E\left(\Delta f x_{\tau;t}\right)\right)\left(1 + z^{f}_{\tau;t}\right). \tag{6.9}$$

Since actual value of the Serbian spot rates are not known (they are approximated using EUR yield curve), forecast of the RSD/EUR is indirectly computed using USD spot rates (for which yield curve is available, too), based on the combination of the UIP and relative PPP concepts. Computation is done under assumption that forecast of domestic and foreign inflation rates are known exogenous inputs (here they are retrieved from the WEO). First, applying USD and EUR spot rates to UIP formula, USD/EUR exchange rate depreciation is forecasted. In the second step, applying relative PPP formula to forecasts of the RSD and EUR inflation, nominal depreciation of RSD/EUR is computed. Eventually, using forecasts of the USD/EUR, nominal depreciation of the RSD/USD is derived. Results of the forecasted exchange rates RSD/EUR i RSD/USD are presented in Table 6.4

Table 6.4: Forecasted interest rates on future issuance of RSD denominated T-bonds, April 2019

Variable	2019	2020	2021	2022	2023	2024
RSD/EUR	118	119.07	120.545	121.84	123.11	124.35
RSD/USD, via EUR	104.4248	108.59	109.87	110.98	112.14	113.09
inflation RSD	2.006	2.5	2.959	3	3	3
inflation EUR	1.31	1.567	1.691	1.883	1.926	1.968

Source: *own calculations*

6.1.2 Stochastic approach to forecasting of all debt determinants

Debt accumulation mechanics implies straightforward transmission of variations in debt drivers to public debt dynamics. Nevertheless, as discussed in the Section 2.3, transmission mechanics gets significantly complex when various interlinks between debt determinants are considered, for instance primary balance is under the influence of economic output, exchange rates are under the influence of interest rates and inflation rate. In addition, the fiscal reaction function defined in (3.10) imposes that primary balance is also responsive to the past values of debt accumulated. Discussion in this subsection revolves around idea that debt determinants should be jointly modeled utilizing correlations patterns observed in historical data. More particularly, econometric strategy utilizes Vector Autoregression (VAR) approach to model non-fiscal debt determinants and FRF setting to model fiscal stance. Opposite to case of deterministic approach, here I provide only methodological aspects of the modeling, while empirical estimations are conducted in the sections 6.3 and 6.4.

VAR Modeling

The pioneering work of Garcia & Rigobon (2004) propose the use of VAR to model the joint dynamics of risk factors driving the public debt. They do not make distinction between different public debt drivers and use a single VAR model including the debt-deficit adjustment instead. Assuming that all risk variables are fully stochastic in nature and correlated to a certain degree, the joint dynamics of risk variables $\boldsymbol{x_t}$ follow a multinomial normal distribution with mean $\boldsymbol{\mu}$ and variance-covariance matrix $\boldsymbol{\Sigma_{xx}}$:

$$x_t \sim N(\mu, \Sigma_{xx}),$$
$$x_t = \{r_t, rg_t, \Delta fx_t, \pi_t, pb_t,\} \tag{4.2}$$

Under the assumption of joint distribution, the VAR model in vector terms reads

$$x_t = c + \sum_{i=1}^{p} A_i x_{t-i} + v_t, \tag{4.3}$$
$$v_t \sim N(0, \Sigma_{vv})$$

where $\boldsymbol{A_i}$ is the matrix with $\boldsymbol{i}$-th lag coefficients, $\boldsymbol{v}_t \sim N(\boldsymbol{0}, \boldsymbol{\Sigma_{vv}})$ and $\boldsymbol{\Sigma_{vv}}$ is variance-covariance matrix of the reduced-form residuals.

However, as the reduced-form residuals are linear combination of structural shocks, they are not suitable for performing the impulse response analysis of innovations in risk variables dynamic, which requires a structural VAR (SVAR) model. The main issue in the structural VAR specification is the identification of the model. As there is no some specific theory about the contemporaneous relations structure, Garcia & Rigobon (2004) use recursive ordering approach by an arbitrarily proposed exogeneity of variables and set a simple *AB* specification of structural VAR model to

$$Av_t = Bu_t \tag{4.4}$$

where *A* is the matrix defining contemporaneous relations (not to be confused with A_i matrices of VAR regression coefficients), u_t represent structural shocks and *B* is the matrix of structural form parameters.

The structural model is identified by orthogonalization of the reduced-form residuals using the Cholesky decomposition (Sims, 1981), $\boldsymbol{\Sigma_{vv}} = \boldsymbol{BB'}$, while matrix $\boldsymbol{A}$ is assumed to be an identity matrix, such that $\boldsymbol{v}_t = \boldsymbol{B}\boldsymbol{u}_t$. As matrix $\boldsymbol{B}$ is a triangular matrix, the last variable will be the most exogenous and thus its innovation will have contemporaneous effects on all variables, while innovation in the first variable will affect only itself.

Later work of Celasun, Ostry, and Debrun (2006) excluded fiscal variables from VAR modeling. Instead, they propose the fiscal reaction function (FRF) for separate modeling of fiscal balance, narrowing range of VAR only to those variables that drive the automatic debt dynamics, in particular: interest rates, growth rates and changes in the exchange rates. In addition, the scope of debt forecasting shifted from point forecast and impulse response analysis to Monte Carlo simulations and fan charts, based on the SVAR. In this work, I also adopted such approach, so that the VAR modeling is limited only to non-fiscal variables.

FRF modeling

For the evaluation of fiscal policy behavior, I rely on the standard literature of FRFs, which encompasses both lagged value of debt and output gap as explanatory variables. Following Celasun, Ostry, and Debrun (2006), I specify the regression model of fiscal reaction in a panel-data form as

$$b_{i,t} = \alpha + \beta d_{i,t-1} + \gamma og_{i,t} + \delta b_{i,t-1} + X_{i,t}\theta + u_{i,t}, \quad (4.5)$$

where

- $b_{i,t}$ is a ratio of government balance to GDP or the fiscal stance;
- $d_{i,t-1}$ is a one-period lagged ratio of debt-to-GDP;
- $og_{i,t}$ is an estimated output gap as a share of potential GDP;
- $X_{i,t}$ is a vector of control variables;
- $u_{i,t}$ is a random error, assumed to be normally independently identically distributed (IID), $u_{i,t} \sim N(0, \sigma_u^2)$;
- essentially, $u_{i,t}$ represent the fiscal policy shocks.

Estimated values of the regression coefficients allow a straightforward interpretation of the fiscal policy behavior. Considering fiscal responsibility, see e.g. Afonso (2008), if

- $\beta > 0$, fiscal policy is responsible;
- $\beta \leq 0$, fiscal policy is ambiguous.

Considering the cyclicality, see e.g. Turrini (2009), if

- $\gamma > 0$, fiscal policy is counter-cyclical;
- $\gamma < 0$, fiscal policy is pro-cyclical;
- $\gamma = 0$, fiscal policy is a-cyclical.

The fiscal balance is usually very persistent. Therefore, the previous studies include lagged balance as an explanatory variable in the FRF, see e.g. Gali & Perotti (2003) and Afonso (2008).

In the context of debt forecasting, the fiscal reaction function can be also used to simulate the development of balance under various scenarios. The underlying idea is to split future fiscal response into a pre-determined part, an automatic part and a random part

$$b_{i,T+h} = \Gamma_{i,T+h} + \beta d_{i,T+h-1} + \gamma og_{i,T+h} + \varepsilon_{i,T+h} \tag{4.6}$$

where $\Gamma_{i,T+h}$ represents the pre-determined part of the fiscal reaction, $\beta d_{i,T+h-1} + \gamma og_{i,T+h}$ is the automatic part (average response of EEC countries' balance to lagged debt and output gap) and $\varepsilon_{i,T+h}$ is the random part (the fiscal policy shock). The predetermined response $\Gamma_{i,T+h}$ is further divided into the aggregate impact of the non-fiscal variables affecting fiscal balance $\mathrm{X}_{\mathrm{i,T}+h}\theta$, and the future fiscal policy actions $\lambda_{i,T+h}$:

$$\Gamma_{i,T+h} = \mathrm{X}_{\mathrm{i,T}+h}\theta + \lambda_{i,T+h} \tag{4.7}$$

Eventually, the fiscal policy shocks $\varepsilon_{i,T+h}$ are assumed to be normally distributed with zero mean and country-specific variance estimated from the FRF regression residuals, $\varepsilon_{i,t} \sim N(0, \hat{\sigma}_{\varepsilon_i}^2)$. The future fiscal policy actions could be calibrated using the information about the expected fiscal policy moves, such as announced fiscal consolidation or fiscal stimulus.

6.2 Forecasts of the costs and risks of public debt

In the previous section I discussed deterministic approach to modeling and forecasting of the debt market determinants. A question that inevitably arise is what is the value added of such approach in practical application? To answer this question, lets recall discussion on gross borrowing requirements and debt funding strategies raised in subsection 2.2.5. The bottom line of this discussion is that the debt accumulation mechanics based on the net lending/borrowing as a measure of fiscal balance is not convenient for the public debt managers, who have the authority to influence forward-looking debt dynamics by managing structure of newly issued debt. Thus, debt funding strategies are rather based on the accumulation of the gross borrowing needs over time, whereby gross borrowing needs represents a sum of net lending/borrowing and existing debt maturing within the reporting period.

Lets also recall that the main objective of the public debt management is to assure a borrowing at lowest possible cost over the medium to long run, consistent with a prudent degree of risk. In practice, this means that the DMO needs to chose weights within gross borrowing requirements for each debt sub-portfolio with respect to the currency and interest rate $\omega_{k,t}^{CS}\omega_{j,t}^{TS}$, as explained in the equation (2.26), which in turn will optimize cost-risk trade-off. In order to assess effects of the variety of possible debt funding strategies on the future costs and risks of the public debt, the DMO needs detailed forecasts of the interest rates, such as provided in tables 6.3a and 6.3b, to vary weights $\omega_{k,t}^{CS}\omega_{j,t}^{TS}$ within the debt funding strategy.

Serbian Public Debt Administration applies cost-risk modeling of the World Bank MTDS framework, to select optimal debt strategy in regard to risk exposure. In line with general idea to test out-of-sample performance of the cost-risk analysis conducted back to 2013, the output of such analysis that was officially published in Serbian Fiscal Strategy for 2013 with projections for 2014 and 2015 is presented in the figures 6.3a and 6.3b.

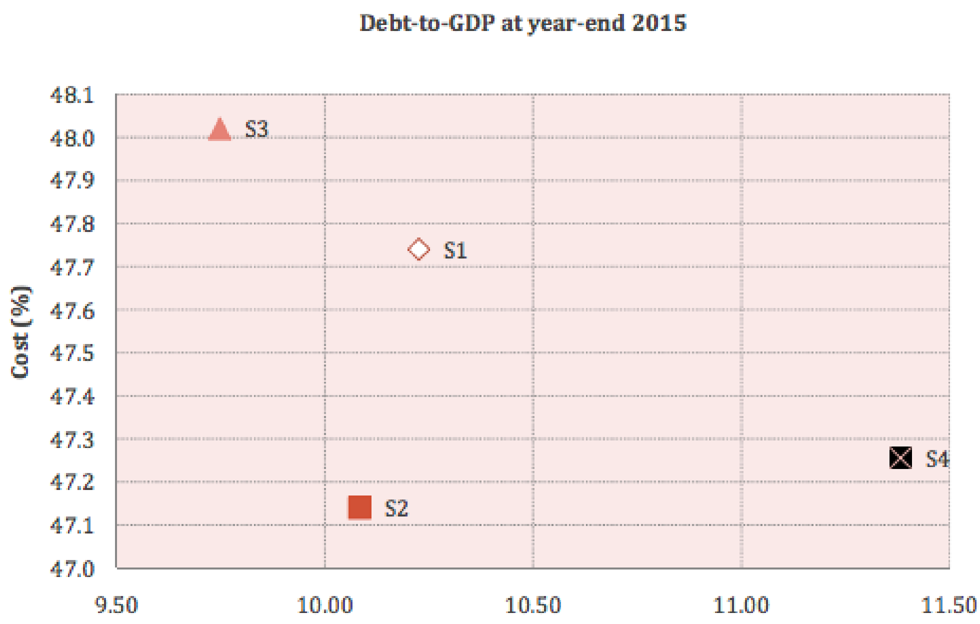


Figure 6.3a: Cost and risk analysis of alternative borrowing strategies in terms of debt-to-GDP ratio, Serbian Debt Strategy, 2013-2015 forecast

Source: *Fiscal Strategy for 2013 with projections for 2014 and 2015*

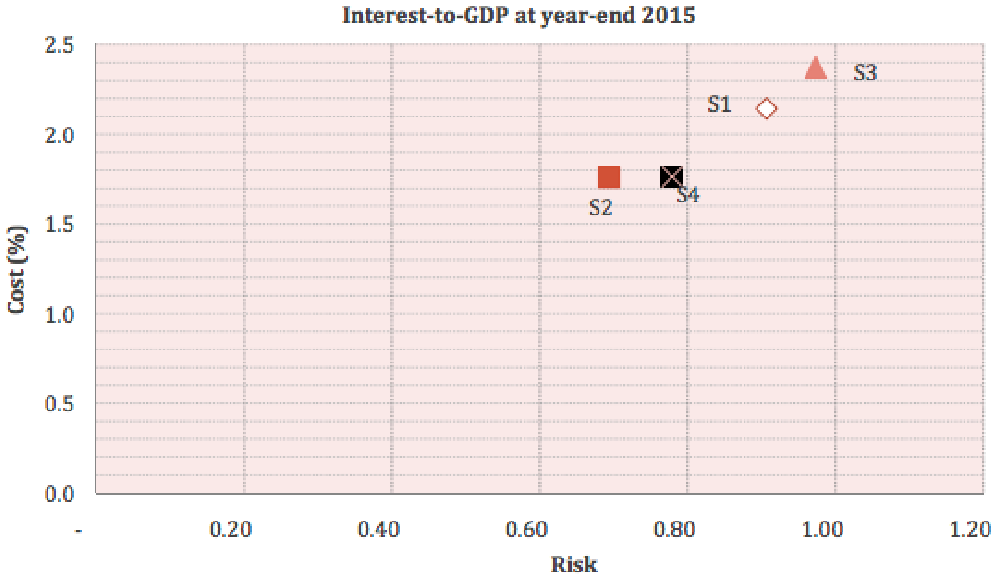


Figure 6.3b: Cost and risk analysis of alternative borrowing strategies in terms of interest-to-GDP ratio, Serbian Debt Strategy, 2013-2015 forecast

Source: *Fiscal Strategy for 2013 with projections for 2014 and 2015*

In this section I recomputed cost-risk measures using PDA data on public debt portfolio and MTDS template, and extend the analysis from 3-year period up to 5-year period (2017), in line with overall research rationale of empirical analysis in this chapter. In the first subsection I elaborate debt funding strategies and macroeconomic scenarios. The second subsection presents the results of the respective cost-risk analysis.

6.2.1 Debt funding strategies and macroeconomic scenarios

The first step in implementation of the MTDS is aggregation of the large number of debt instruments to sub-portfolios according to the common properties with respect to the key aspects of public debt structure characteristics, discussed in Chapter 2. This aggregation to sub-portfolios according to the MTDS scheme is presented in the Table 6.5.

Table 6.5: Structure of the Serbian public debt by the end of 2012

MTDS code	Instrument Type	Interest rate type	Maturity	Nominal IR	Currency	Residence type	Outstanding debt (mil RSD)	Share in total debt
USD_1	Loan	Fix	20	0.75%	USD	External	112,861	6.80%
EUR_3	Loan	Var	20	0.90%	EUR	External	337,287	20.31%
USD_5	Loan	Var	20	2.80%	USD	External	0	0.00%

EUR_6	T-Bill	Var	1	6.15%	EUR	External	99,232	5.98%
EUR_7	T-Bond	Fix	3	6.32%	EUR	External	39,282	2.37%
EUR_8	Loan	Fix	22	5.00%	EUR	External	519,048	31.26%
RSD_9	T-Bills	Var	1	10.50%	RSD	Domestic	105,323	6.34%
RSD_10	T-bonds	Fix	2	14.00%	RSD	Domestic	84,619	5.10%
RSD_11	T-bonds	Fix	3	15.75%	RSD	Domestic	94,206	5.67%
RSD_12	T-bonds	Fix	5	16.00%	RSD	Domestic	14,454	0.87%
USD_13	Eurobond	Fix	10	6.65%	USD	External	253,994	15.30%
EUR_14	Eurobond	Fix	5	6.93%	EUR	External	0	0.00%

Source: MTDS computation using PDA data

As explained in the Fiscal Strategy for 2013 with projections for 2014 and 2015, four debt funding strategies were regarded:

- **Basic strategy S1: funding using existing instruments.** The majority of new borrowing is based on issuing government securities in local and foreign currencies in the domestic market and issuing Eurobonds denominated in US dollars;
- **Strategy S2: 5-year Eurobond in EUR.** In addition to the existing 10-year Eurobond denominated in USD, 5-year Eurobond denominated in EUR will be issued (coded as EUR_14);
- **Strategy S3: large-scale dinarization**. Increased issuing of dinar-denominated government securities;
- **Strategy S4: full-scale dollarization.** financing needs in the period 2013–2015 are fully covered by Eurobonds denominated in US dollars, without borrowing in the domestic market or in local currency.

The funding strategies are formalized in quantitative terms and presented in the Table 6.6.

Table 6.6: Debt funding strategies 2013 -2015, envisaged by Fiscal Strategy for 2013

MTDS code	S1: current instruments	S2: 5-year Eurobond	S3: large-scale dinarization	S4: full-scale dollarization
EUR_3	19.78%	19.78%	17.09%	20.00%
USD_5	5.56%	5.56%	4.16%	9.00%
EUR_6	7.42%	7.42%	5.54%	19.00%
EUR_7	3.09%	3.09%	2.31%	10.00%
RSD_9	19.10%	19.10%	26.90%	0.01%
RSD_10	7.64%	7.64%	10.76%	0.00%
RSD_11	7.64%	7.64%	10.76%	0.00%
RSD_12	3.82%	3.82%	5.38%	0.00%

USD_13	25.96%	0.00%	17.09%	21.00%
EUR_14	0.00%	25.96%	0.00%	21.00%
Total External	61.80%	61.80%	46.20%	100.00%
Total Domestic	38.20%	38.20%	53.80%	0.00%

Source: MTDS computation using PDA data

The next step in analysis is conjecture of the baseline macroeconomic scenario. Within MTDS, projections of the inflation, GDP and primary balance are also considered as exogenous inputs, retrieved from the credible sources such as the World Economic Outlook database of the IMF. On the other side, interest and exchange rates are forecasted using very similar deterministic approach as described in the previous section. In case of interest rates, the main difference is a way in which risk premiums are calibrated, while in case of exchange rates main difference is that projection of the EUR/USD exchange rate is also exogenous input. The forecasted term structure of future spot rates per sub-portfolios covered by MTDS analysis is given in the Table 6.7:

Table 6.7: Forecast of future spot rates on Serbian public debt instruments in 2012, baseline scenario

	2013	2014	2015	2016	2017
USD_1	0.75%	0.75%	0.75%	0.75%	0.75%
EUR_3	0.52%	0.79%	1.21%	1.73%	2.11%
USD_5	0.48%	0.60%	0.98%	1.59%	2.85%
EUR_6	6.27%	6.54%	6.96%	7.48%	7.86%
EUR_7	6.59%	6.99%	7.44%	7.86%	8.13%
EUR_8	2.00%	2.00%	2.00%	2.00%	2.00%
RSD_9	12.50%	11.50%	10.50%	9.50%	8.50%
RSD_10	13.00%	12.00%	11.00%	10.00%	9.00%
RSD_11	14.75%	13.75%	12.75%	11.75%	10.75%
RSD_12	15.00%	14.00%	13.00%	12.00%	11.00%
USD_13	6.88%	7.11%	7.35%	7.55%	7.72%
EUR_14	7.28%	7.67%	8.01%	8.32%	8.60%

Source: MTDS computation using PDA data

In the last step, four alternative risky scenarios are arbitrary defined for the purpose of debt sensitivity analysis as described in the Chapter 2. All scenarios assumed deviations from the baseline that start in 2014. These scenarios are:

- **Scenario 1: Depreciation of the dinar against the dollar by 25%.** The rationale of this scenario was anticipation that recovery of the USA will result in USD global appreciation;
- **Scenario 2: Depreciation of the dinar against EUR and USD 25%.** The rationale of this scenario was anticipation that current account deficit needs to be reduced, which in turn will result in RSD depreciation;
- **Scenario 3: Arbitrary jump in all interest rates.** The rationale of this scenario was anticipation that all interest rates after the global economic recovery will increase;
- **Scenario 4: Interest rate increase by 5% on RSD debt.** The rationale of this scenario was assumption that domestic inflation will remain highly volatile.

6.2.2 Cost-risk metrics

In this subsection I provide results of the cost and risk estimation of the Serbian public debt for the period 2013-2017, in regard to the debt funding strategies and macroeconomic scenarios. Since the needed exogenous forecasts of the primary balance and GDP for 5-year time horizon goes beyond 3-year forecasts given in Fiscal Strategy, I used compatible forecasts from WEO available in 2012. The projections of the debt and costs are provided in the tables 6.8a and 6.8b:.

Table 6.8a: Costs of alternative borrowing strategies in terms of debt-to-GDP ratio, Serbian Debt Strategy, 2013-2017 forecast

Scenarios	S1	S2	S3	S4
Baseline	57.0	57.1	57.2	57.2
Exchange rate shock against USD and EUR (25%)	68.2	68.3	67.7	69.8
Interest rate shock 1 (Yield curve up)	60.0	60.1	60.3	59.8
Interest rate shock 2 (Yield curve up)	61.2	61.4	61.2	61.6
Combined shock (25% depreciation and interest rate shock 1)	64.1	63.1	63.9	63.8

Source: MTDS computation using PDA data

Table 6.8b: Costs of alternative borrowing strategies in terms of interest-to-GDP ratio, Serbian Debt Strategy, 2013-2017 forecast

Scenarios	S1	S2	S3	S4
Baseline	3.0	3.1	3.2	2.8
Exchange rate shock against USD and EUR (25%)	3.6	3.7	3.8	3.4

Interest rate shock 1 (Yield curve up)	4.3	4.4	4.6	3.9
Interest rate shock 2 (Yield curve up)	4.8	4.9	5.0	4.7
Combined shock (25% depreciation and interest rate shock 1)	4.5	4.5	4.8	4.1

Source: MTDS computation using PDA data

In the next step, associated risk is computed. The rational of the risk metrix is that for the given financing strategy, risk is computed as the maximal difference between baseline scenario and alternative scenario. This is illustrated in the tables 6.9a and 6.9b.

Table 6.9a: Risks of alternative borrowing strategies in terms of debt-to-GDP ratio, Serbian Debt Strategy, 2013-2017 forecast

	S1	S2	S3	S4
Scenarios	0	0	0	0
Baseline	11.1	11.1	10.5	12.7
Exchange rate shock against USD and EUR (25%)	2.9	2.9	3.1	2.6
Interest rate shock 1 (Yield curve up)	4.2	4.2	4.0	4.5
Interest rate shock 2 (Yield curve up)	7.0	6.0	6.8	6.7
Combined shock (25% depreciation and interest rate shock 1)	11.1	11.1	10.5	12.7

Source: MTDS computation using PDA data

Table 6.9b: Risks of alternative borrowing strategies in terms of interest-to-GDP ratio, Serbian Debt Strategy, 2013-2017 forecast

	S1	S2	S3	S4
Scenarios	0	0	0	0
Baseline	0.5	0.6	0.5	0.6
Exchange rate shock against USD and EUR (25%)	1.3	1.3	1.4	1.1
Interest rate shock 1 (Yield curve up)	1.8	1.8	1.8	1.9
Interest rate shock 2 (Yield curve up)	1.5	1.4	1.6	1.4
Combined shock (25% depreciation and interest rate shock 1)	1.8	1.8	1.8	1.9

Source: MTDS computation using PDA data

From this analysis, it can be concluded that the most risky debt funding strategy is S4 which envisaged full-scope funding of gross borrowing needs by foreign debt.

6.3 Econometric modeling of the fiscal reaction function

As elaborated in the Literature Review section, there is a lot of the empirical indications that fiscal policy stance of Central and Eastern European economies, in this work referred to as Emerging Europe, was profoundly pro-cyclical and expansive prior to global crisis outbreak. In order to test hypotheses that EEC governments were forced to shrink their primary balance in response to rising public debts and that continuation of the pro-cyclical fiscal policy would result in unsustainable debt paths, in this section I estimated fiscal reaction function for the EEC. More particularly, I use broader sample of 21 EEC in order to get more accurate estimation of average fiscal response. The econometric estimation is based on the model specification presented in the first subsection of this chapter. Following the overall rationale of the analysis in this chapter, the FRF is estimated using yearly macroeconomic dataset (referred to as DS2) from the WEO available prior to 2013[36]. The first subsection discusses stylized facts on debt dynamics and economic fluctuations in the pre- and post-crisis period. Second subsections deals with econometric issues of the FRF estimation. The last two subsection provides estimation results and their interpretation.

6.3.1 Cyclicality and indebtedness in Emerging Europe – stylized facts

During the boom years of the 2000s, many Emerging European countries experienced large capital inflows that fueled extensive corporate and household borrowing. The bursting of the credit bubbles and the resulting economic shocks following the outbreak of the 2008 global financial crisis took a toll on household, corporate, and public balance sheets in the region. By looking at the aggregate data on private and public debt and growth, it is possible to clearly distinguished two phases in the evolution of EEC indebtedness: the run-up to the crisis and the aftermath of the crisis.

Run-up to the crisis (2003-07)

In 2003-07, private debt in EEC increased substantially – corporate debt increased by 20 percent of GDP on average in the EU New Member States (NMS) and household sector debt increased by 17.5 percent of GDP due to very rapid credit growth (Figure 3.2). Rapid credit growth was generally driven by catch-up process with advanced European countries, as during the 00’s considerable number of EEC countries became the members of European Union. World Bank (2007) study find that rapid credit expansion across the EEC region was a consequence of the financial integration and deepening; yet, Baltics and Southeastern European NMS experienced an outright credit boom with strong detrimental

[36] It should be noticed that prior to 2013, only data according to ESA 95 were available.

effects on macroeconomic variables, creating bubbles in asset prices, distorting labor markets and contributing to large external imbalances and real exchange rate appreciation.

With a notable exception of Montenegro, the Balkans (Western Balkan countries without Croatia) were in a more favorable position than the NMS in terms of the level of debt and its rate of growth. On average, private sector debt in the Balkan countries was about 60 percent of GDP in 2007 whereas in NMS it was more than 90 percent of GDP. The growth of private debt was followed by rapid growth of real GDP. In 2003-2007, real GDP of EEC increased on average for 29% (cumulatively). The increase in debt was counterpart of stabilization of government deficits and public debt. Strong economic growth and increase in revenues and investments of corporates and income and consumption of households reflects positively on public finance. In the same period, public sector debt declined in 2003-07 in all emerging Europe countries except Hungary and Belarus.

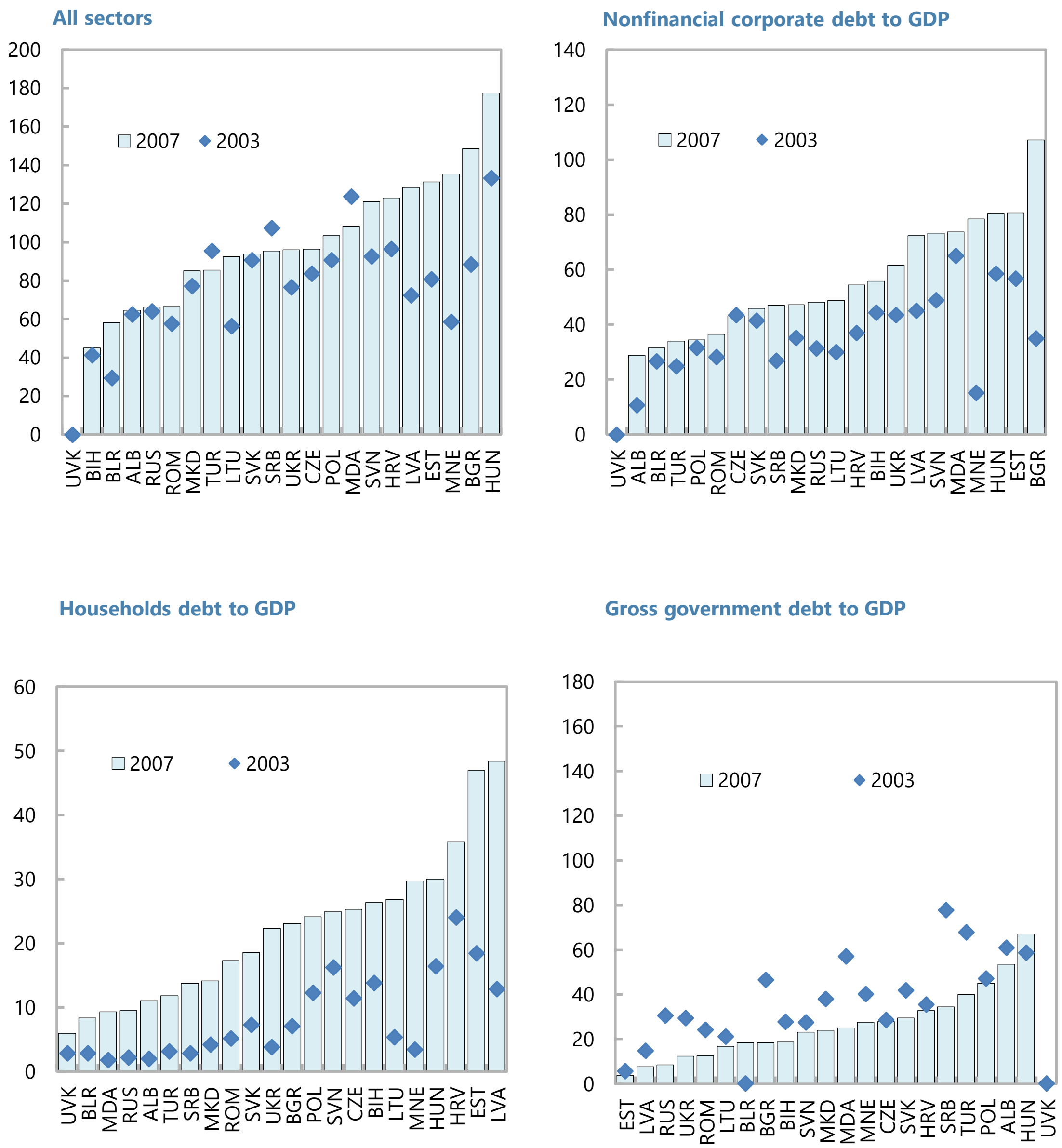


Figure 6.4: Debt by sector in EEC, 2003-2007

Source: *DS2*

Aftermath of the crisis

McKinsey (2010, 2012) point role of increase in private debt to decrease of subsequent economic activity and two distinct phases of deleveraging as a necessary condition for economic recovery: the first, households, corporations, and financial institutions reduce debt significantly over several years, while economic growth is negative or minimal and government debt rises, while in the second phase, growth rebounds and government debt is reduced gradually over many years. This is exactly what was happening in the aftermath of the crisis. The rapid growth of household and corporate debt suddenly stooped following the sharp fall in economic activity, and by the end of 2011 some EEC countries already saw the beginning of the private debt deleveraging (Figure 3.3). On the other hand, public debt in most of the EEC began slowly but steadily to rise, as a consequence of the rising fiscal deficits.

At the end of the day strong cyclical fluctuations created by large inflow and sudden stop of capital inflows leads to co-movements and tremendous cross-country correlation between macroeconomic variables in EEC, which is illustrated in more details further in the text.

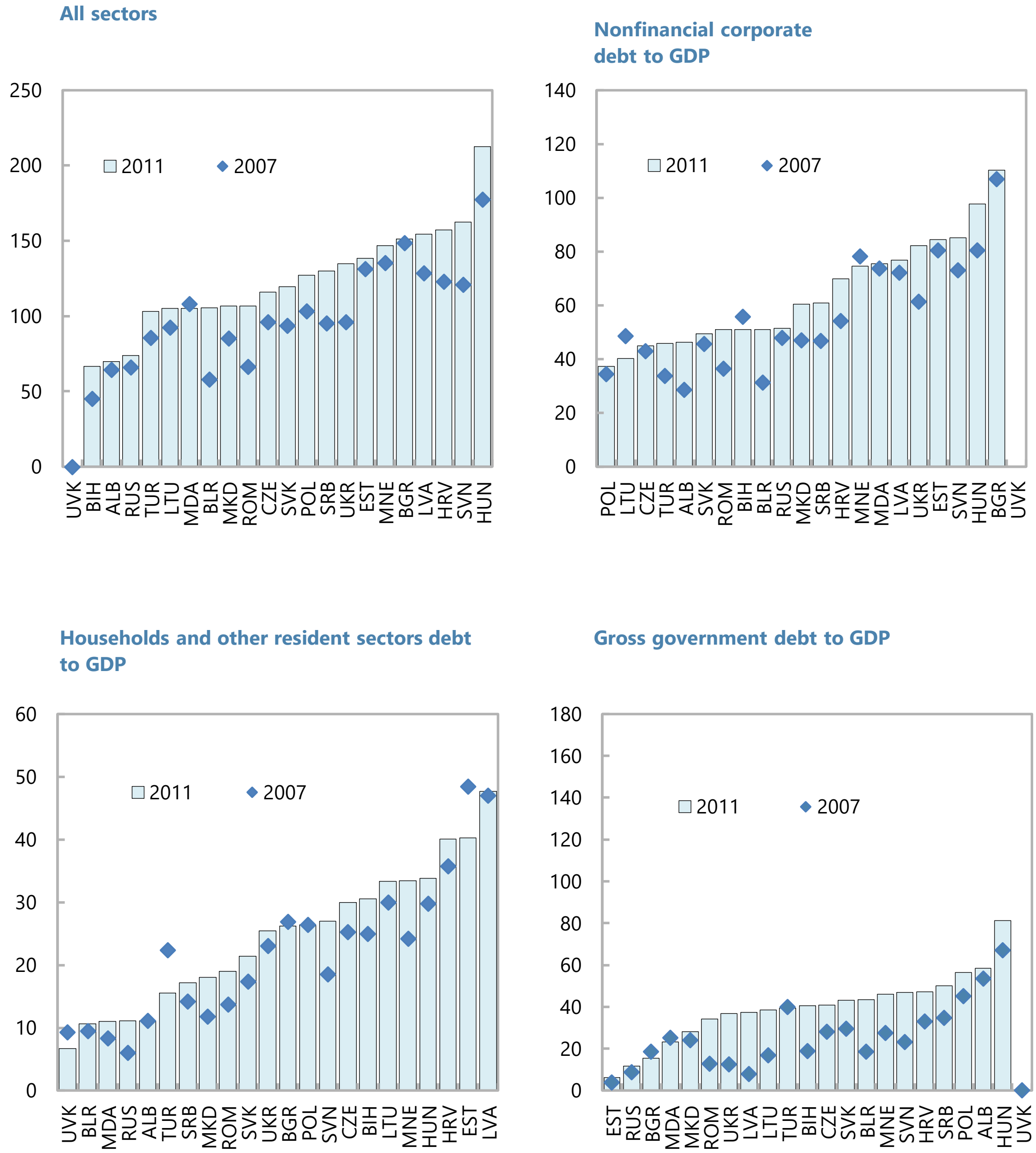


Figure 6.5: Debt by sector in EEC, 2007-2011

Source: *DS2*

6.3.2 Econometric issues and control variables

The typical econometric issue when it comes to macroeconomic panel models is endogeneity. Explanatory variables could be endogenous to errors in the model due to reverse causality i.e. dependence of lagged debt on accumulated past values of primary balance. If capacity to generate primary surplus is time-invariant and differs across countries, then error term $\mathrm{u}_{\mathrm{i,t}}$ in the equation (4.5) will consists of an idiosyncratic error $\nu_{i,t}$ and a country-specific effect η_i . Therefore, the lagged values of debt will be endogenous to $u_{i,t}$. Even if the individual country effects are removed by time-demeaning of the data, having serially correlated policy shocks $E(u_{i,t}u_{i,t-1}) \neq 0,$ lagged debt will be an endogenous variable as $E(pb_{i,t-1}u_{i,t}) \neq 0$. Celasun, Ostry, & Debrun (2006) discuss the endogeneity issues in estimating fiscal reaction in detail and notice that these two endogeneity sources will trigger a downward bias in the OLS estimation of β, since higher country specific capacity to generate surplus or positive realizations of the idiosyncratic shocks would both tend to reduce the stock of public debt.

They also point to the third possible source of endogeneity, i.e. that output gap may be endogenous to the contemporaneous fiscal policy shocks, $E(og_{i,t}u_{i,t}) \neq 0$. Another issue of endogeneity arises when lagged dependent variable is added to the model with country-specific effects, as it is inevitably correlated with the error term for the same reason as in case of the lagged debt. Thus, a pooled OLS estimator applied to the model (4) would most likely produce the inconsistent estimations.

Apart from output gap and the level of indebtedness, additional factors might influence the government decisions on discretionary measures of fiscal policy. They can be divided in three categories: economic, institutional and political, and common factors.

Regarding the economic factors, current account and inflation rate are shown to be significant explanatory variables, see European Commission (2011) and Eller & Urvova (2012). The institutional and political factors of relevance include political conditions such as elections, size of the government's parliamentary majority, government fragmentation and the Fiscal Rules Index (FRI), an indicator of institutional quality and average strength and coverage of fiscal rules in each country, see European Commission (2011). Finally, the common factors affecting all the countries in a sample can be institutional factors such as the signing of the Maastricht Treaty in 1992, see Turini (2008), the oil prices, see Celasun, Ostry & Debrun (2006), or global crisis spillovers, see Eller & Urvova (2012).

Finally, all these factors are taken into consideration as much as possible. Regarding the economic factors, I choose the terms of trade to account for international competitiveness, the country openness to account for the impact of foreign business cycles, the private investments to account for the domestic business conditions and inflation to account for the monetary policy actions. To the best of our knowledge, there are no consistent indicators of institutional quality and political factors for the EEC in my sample except of parliamentary elections cycles. That particular variable is the most frequently used political factor in the FRF estimations, see for example Afonso (2008), Afonso & Hauptmaier (2009) and Turini (2008). Regarding the common factors, I account for the outbreak of the global financial crisis that likely had strong adverse impact on economic activity in the EEC, interrupting the credit-driven economic boom until 2008 and resulting in widely opened output gaps in 2009.

6.3.3 Estimation results

I applied Fedelino, Ivanova & Horton (2009) approach to adjust overall and primary government balance, as their assumptions considerably eliminate needs for longer series of disaggregated data on government revenue and expenditure that could not be gathered from a unique source. That is also in line with finding of Markus Eller (2009) that in the 10 CEE countries the average elasticity of government revenue and expenditure was 0.94 and -0.1, respectively, for the period 1995-2004.

Fiscal reaction function in equation is estimated in several versions depending on the choice of the left-hand-side variable (non-adjusted vs. adjusted, overall vs. primary), the scaling factor of the left-hand-side variable (potential vs. actual GDP) and the estimation method. Regarding the estimation method, I consider the panel regression with fixed effects - FE, the two-stage least squares - 2SLS (Instrumental Variables) and the one-step Arellano & Bond (1991) - AB (Generalized Method of Moments). The estimates of standard errors are robust to heteroscedasticity and intra-group correlation. In the 2SLS estimation, fixed effects are removed and debt and output gap are instrumented by the lagged values of the explanatory variables, which is usual approach in the literature, see e.g. Medeiros (2012). The Stock-Yogo maximal relative bias procedure is applied to test whether the instruments are weak in case of the 2SLS estimation The validity of the instruments is tested by Hansen J test in case of the IV 2SLS estimation. The validity of instruments in AB GMM estimation is checked using AR(1) and AR(2) tests of the first-differenced errors as the Hansen-Sargan test is prone to over-rejection in case of heteroscedasticity (see Arellano & Bond,1991).

The estimated regression coefficients for the full sample are presented in Table 6.10. The results show that the primary balance responds positively to lagged debt. An increase in debt-to-GDP ratio of one percentage point implies an increase in the balance of 3-6 basis points in the following year, which is comparable with the results in the literature on EEC. Positive response indicates that, in general, EEC governments behaved responsibly during the period of observation. The non-adjusted primary balance seems to react a-cyclically to the output gap. Moreover, this reaction appears to be even counter-cyclical when estimated by FE and 2SLS estimators. After adjustment, a-cyclical and counter-cyclical responses become strongly pro-cyclical throughout the sample. Altering actual GDP with potential as a scaling factor does not affect the estimated coefficients, so these estimations are omitted from the tables.

Table 6.10: Estimation of Fiscal Reaction Function – full sample

Estimator	FE		IV 2SLS		AB GMM	
Dependent var	capb	pb	capb	pb	capb	pb
L.gd	0.0396**	0.0385**	0.0619**	0.0569*	0.0282**	0.0411***
lagged debt	(0.0158)	(0.0158)	(0.03)	(0.0295)	(0.0124)	(0.012)
og	-0.2202***	0.1300*	-0.2276***	0.1238**	-0.1863***	0.0466
output gap	(0.0725)	(0.0751)	(0.0461)	(0.0491)	(0.0348)	(0.0458)
gcr	-0.0239***	-0.0252***	-0.0260***	-0.0271***	-0.0084	-0.0274***
crisis dummy	(0.0055)	(0.0054)	(0.0053)	(0.0052)	(0.0052)	(0.0043)
elec	-0.003	-0.0032	-0.003	-0.0029	-0.0007	-0.0002
election dummy	(0.0023)	(0.0023)	(0.0026)	(0.0026)	(0.0025)	(0.0024)
d_tot	0.0002	0.0003*			0.0003	0.0006*
change in terms of trade	(0.0002)	(0.0001)			(0.0003)	(0.0003)
open	0.015	0.0153			0.0051	0.0094
openness	(0.0194)	(0.0192)			(0.0104)	(0.01)
pr_inv	0.0072	0.0237			-0.0814	-0.0515
private investments	(0.0844)	(0.0888)			(0.0525)	(0.0583)
infl	0.0249	0.027			0.0505***	0.0236
inflation	(0.0371)	(0.0344)			(0.0184)	(0.0162)
L.capb					0.5172***	
lagged capb					(0.0664)	
L.pb						0.5110***
lagged pb						(0.0822)
Cragg-Donald			60.541**	60.541**		
Hansen J			5.099	5.576		
AB AR(1) z					-2.58***	-2.65***
AB AR(2) z					0.22	0.36
No. of Obs.	238	239	229	229	208	210
R-Squared	0.55	0.54	0.29	0.24		

Notes: Standard errors in the parenthesis;
*levels of significance: * p<0.1, ** p<0.05, *** p<0.01*

Source: *own calculation*

The baseline estimation is further extended to the subsamples of “good” and “bad” times. This kind of approach is similar to Turrini (2008), but differs in definition of good and bad times. Turrini (2008) characterized years in which output gap has positive sign as good times, an opposite for bad times. Considering the clear cyclicality in economic fluctuations prior and following the crisis, I simply define the sub-period of economic expansion 2000-

2008 as good times, and the sub-period of decline and stagnation 2009-2012 as bad times. The results of good and bad times analysis (only for cyclically adjusted values of balance) are presented in the Table 6.11. However, good and bad times analysis reveals that strong positive response (ranging from 0.1 to 0.3 pp.) of primary balance is observed only in bad times, while response seems to be non-systematic and even negative in good times. The lack of response in good times is not necessary problematic, under reasonable assumption that period of stable or declining debt coincides with economic boom. Effect of automatic adjustments seems to be irrelevant for the size and direction of response of primary balance to lagged debt.

Table 6.11: Good and Bad Times Analysis

	capb, IV 2SLS		capb, AB GMM	
	2000-2008	2009-2012	2000-2008	2009-2012
L.gd	-0.019	0.272***	-0.0057	0.101**
	(0.0234)	(0.0594)	(0.0195)	(0.045)
og	-0.384***	-0.2318	-0.217***	-0.1035
	(0.0592)	(0.2101)	(0.0415)	(0.0745)
elec	-0.0025	-0.0039	-0.0029	0.0012
	(0.0039)	(0.0055)	(0.0037)	(0.0036)
d_tot			0.0002	0.0004
			(0.0003)	(0.0003)
open			0.0395***	0.0232
			(0.0152)	(0.024)
pr_inv			-0.1919**	-0.172**
			(0.0874)	(0.0815)
infl			0.1114*	-0.0012
			(0.0592)	(0.0204)
L.capb			0.4931***	0.2580***
			(0.0853)	(0.0936)
L.caob				
Cragg-Donald	30.483**	5.42		
Hansen J	10.167**	5.738		
AB AR(1) z			-2.08**	-2.07**
AB AR(2) z			0.09	-0.85
No. of Obs.	137	80	116	80
R-Squared	0.35	0.32		

Notes: Standard errors in the parenthesis;
*levels of significance: * p<0.1, ** p<0.05, *** p<0.01*

Source: *own calculation*

The good and bad times analysis reveals that pro-cyclical reaction has not been detected in bad times, which is opposite to usual finding that fiscal policy is particularly pro-cyclical in bad times (Gavin & Perotti 1997; Perotti 2007). On the contrary, pro-cyclical reaction was especially pronounced during good times, when increase in the output gap for one percentage point was followed by 0.2-0.4 pp. decrease in balance. Term “increase” here means that incremental change of output gap is a positive value, and should not be confused with term “widening”, which means increase in absolute value of output gap.

Our results on the pro-cyclicality are supported by findings of other studies particularly appraising fiscal behavior in the EEC countries, using analytical tools different than FRF. Darvas (2010) argues that positive response of government consumption to GDP shock is an indicator of pro-cyclical bias in fiscal policy. He estimates SVAR models for 20 EEC countries, and finds that impulse responses of government consumption to unexpected GDP shocks were pro-cyclical, with a few exceptions. Rahman (2010) estimates the relationship between revenues and expenditures with respect to output and domestic demand in CEE 10 and Croatia for the period 1995-2007 and provides evidence on pro-cyclical behavior of revenues, especially pronounced during the years of economic boom (2003-2007). The IMF (2012) country-by-country analysis of EEC macroeconomic performance also supports view that fiscal behavior in the EEC during the boom years was predominantly pro-cyclical, with Hungary as an exception.

The estimated responses of primary to other regressors is mostly in line with the theory. The outbreak of the global financial crisis caused a drop in both primary and overall balances in 2009. This result holds across various specifications of the estimated FRF. The effects of election cycles on balances are negative, as expected, but only occasionally significant. Interestingly, Eller & Urvova (2012) obtain similar results in a comprehensive treatment of election cycles that uses six election indicators to control for the effects of early elections and spending in year preceding election. Fixed effects and Arellano-Bond estimations show that none of the economic factors is significant.

6.3.4 Pro-cyclicality discussion

This subsection provides some of the possible explanations of fiscal pro-cyclicality in the EEC:

Political economy factors. The political factors are likely to be very important cause of pro-cyclical behavior in the EEC. Many of these countries are likely to display a weak institutional framework inherited from previous political and economic systems. However, the key difficulty in estimating the impact of political economy factors is to measure the prudency of fiscal policy. Alesina et al. (2008) propose the corruption index as an indicator of government policy credibility. Although they show a significant association of the corruption index and fiscal policy behavior, their index is still an indirect and qualitative measurement of government dedication to implement a prudent fiscal policy. For this purpose, use of the budget balance forecast errors can make a stronger connection between political motivation and economic results. If government is trying to maintain high approval rates, it has an incentive to reveal overoptimistic forecasts. In such a case, the forecast errors of the budget balance are likely to be higher, especially in good times when the fiscal space for excessive deficits is large. Empirical research on this issue is scarce but confirms this consideration. Most notably, Frankel (2011a) finds that positive biasness of budget balance forecasts is pronounced during good times and pro-cyclical fiscal policies. Similar research applied to EEC is a good starting point for further analysis of political economy factors and the cyclical response of balances.

Credit constraint argument. This argument is likely to be the least important among possible causes of pro-cyclical fiscal policy. To begin with, the perceived riskiness of the region was declining during the period from 2003 to 2008 with CDS spreads reaching very low levels, see Bakker & Gelde (2010). Secondly, the patterns of emphasized pro-cyclicality in bad times due to credit constraints in the Latin American countries, see for example Gavin & Perotti (1997) or Daude et al. (2010), do not correspond to those observed in the EEC. Third, there is no evidence that any of the EEC governments tend to over-borrow in the period of prosperity. As shown in Becker et al. (2010), the share of government debt to GDP was stable or declining in most of the EEC during the period from 2003 to 2008.

Beyond-the-cycle factors. I conjecture that commodity prices are not relevant for the EEC. With the exception of Russia, these countries are typically not export-oriented. On the contrary, asset prices and output composition are arguably important determinants of fiscal behavior in the EEC. The EEC most likely experienced asset prices and absorption booms in previous two decades and in particular from 2003 to 2008. In the run up to the Global financial crisis, the house prices rose faster in some EEC, especially in the Baltics, than in the US, see Walterskirchen (2010). Yet, the correction of balances for automatic response to absorption cycle according to existing methodologies, such as IMF (2007) or Lendvai, Moulin & Turrini (2011), would be too challenging in the case of the EEC. The reason is that there is a large number of required inputs such as budget sensitivity to output gap and to absorption gap or the share of indirect revenues. The association of the absorption cycle to pro-cyclical policy has been previously documented in the emerging economies, see Dobrescu & Salman (2011), and in the EEC during the pre-crisis years, see Rahman (2010) and IMF (2007).

6.4. Public debt dynamics forecasting

The basic idea behind debt accumulation forecasting is to model its two main components, the interest rate-growth differential and the cyclically adjusted primary balance, separately. As discussed, a reason for separation is to account for different types of economic policy decisions and different risk factors that drive these debt aggregates. Therefore, the h-step ahead point forecast of debt d_{T+h} is computed as a sum of h-step ahead forecasts of interest rate-growth differential, i.e. the automatic change of debt $(1 + r_{T+h} - rg_{T+h})$, and the primary balance pb_{t+h}

$$d_{T+h} = (1 + r_{T+h} - rg_{T+h})d_{T+h-1} - pb_{T+h} \tag{4.8}$$

The interest rate growth differential is forecasted using Vector Autoregression (VAR) framework along the lines of Celasun, Ostry, and Debrun (2006), whereas the primary balance is forecasted using the fiscal reaction function.

Following overall approach of out-of-sample analysis, public debt dynamics is forecasted for the period 2013-2017. Since the data time series for some macroeconomic variables in Serbia are substantially shorter relative to other peer countries in the EEC 8 sample, and thus VAR modeling substantially less reliable, for the sake of this analysis I substitute Serbia with Poland within EEC 8 sample. In addition, since back to the beginning of 2013 macroeconomic data were available only according to the ESA 95, I used dataset denoted as DS3, which is basically the same as DS1 in terms of variable coverage but with original ESA 95 data. Since ESA 95 has been discontinued after 2013, for the sake of out-of-sample comparison ESA 2010 data are used, but this should not be an issue for the out-of-sample analysis because there correlation of the ESA 95 and ESA 2010 data in the overlapping period is almost 99%.

6.4.1 VAR-FRF forecasting framework

I propose the following procedure to generate the synthetic debt projections, combining the VAR and the FRF framework. The procedure consists of the following building blocks:

1. Estimation of VAR coefficients and Cholesky decomposition of the variance-covariance matrix of the reduced-form residuals, $\mathbf{\Sigma_{vv}} = \boldsymbol{BB'}$, for the non-fiscal variables;

2. Simulation of the sequence of random vectors $\{\boldsymbol{v}_{T+h}\}$ up to the forecasting horizon $\boldsymbol{H}$, $h = 1, \dots H$, to generate non-fiscal shocks. Simulations are based on the standard normal distribution, $\boldsymbol{v}_{T+h} = \boldsymbol{B}\boldsymbol{u}_{T+h}$, $\boldsymbol{u}_{T+h} \sim N(0,1)$.

3. For each simulated sequence of non-fiscal shocks, the values of non-fiscal variables are forecasted as

$$x_{T+h} = c + \sum_{i=1}^{p} A_i x_{T-i+h} + v_{T+h}; \tag{4.9}$$

4. Modeling of cyclically-adjusted primary balance' response to output gap and lagged public debt, using the FRF setup as given in equation (4.5);

5. For each simulated path of forecasted non-fiscal variables, the cyclically-adjusted primary balance and debt increment and are simultaneously computed in recursive manner, up to the forecasting horizon *H*:

$$capb_{i,T+h} = \Gamma_{i,T+h} + \beta d_{i,T+h-1} + \gamma og_{i,T+h} + \delta capb_{i,T+h-1} + \varepsilon_{i,T+h}; \tag{4.10}$$

$$d^p_{T+h} - d^p_{T+h-4} = \frac{r_{T+h} - \pi_{T+h}\left(1 + rg^p_{T+h}\right) - rg^p_{T+h}}{\left(1 + rg^p_{T+h}\right)\left(1 + \pi_{T+h}\right)} d^p_{T+h-4} - capb_{i,T+h}. \tag{4.11}$$

The debt accumulation equation is specified to fit annualized quarterly data used in the sample. Calibration of the predetermined response of primary balance $\Gamma_{i,T+h}$ under the different assumptions on fiscal policy actions is further discussed in the following sections.

Having the primary balance separately modeled, the VAR modeling is reduced to non-fiscal variables that enters the DAE:

$$x_t = \left\{r_t, rg^p_t, \Delta fx_t, \pi_t\right\} \tag{4.12}$$

It corresponds to the selection of explanatory variables in empirical model estimated in the third chapter. My specification is close to Celasun et al. (2006), but distinctive in several ways. First, I use implied interest rate which eliminates the need to have both domestic and foreign interest rates in the model. Second, I bring back inflation to the VAR, having found that inflation has significant influence on public debt dynamic in panel regression modeling. In addition, I substitute actual with potential GDP growth rate, following the model shifts from actual to structural values.

6.4.2 Unit root testing

The theory of multivariate time-series modeling approves the use of the basic VAR approach only if all the model variables follow the weak stationary stochastic process. I discuss and analyze the issues of stationarity and unit root testing related to panel regressions in the third chapter. The unit root tests in panel regressions consider the null that all panels are non-stationary against the alternative that some panels are stationary. While this may work for the requirements of the panel regression, the VAR modeling on the country level requires more rigorous testing of the stationarity of individual time-series.

To examine the univariate stationarity of the time-series, I use the two alternatives: the Augmented Dickey-Fuller (ADF) test and the Zivot-Andrews (ZA) test. The former test is the most frequently used test in the time-series analysis and here I apply it as the primary unit root test. The latter test provides more reliable inference on stationarity of time-series in the presence of structural breaks and I apply it whenever a time-series is suspected to exhibit a structural break according to the figures presented in the previous chapter. I report the results of the unit root testing in the Table 6.12.

Table 6.12: Non-fiscal variables unit root tests for EEC 8

	r_t		rg_t^p		Δfx_t		π_t	
	break	stat	break	stat	break	stat	break	stat
BGR	no	-1.541**	2008Q2, interc.	-5.123**	no	-2.062**	no	-0.98
HRV	no	-2.786***	2007Q4, interc.	-5.293***	no	-2.975***	2009Q3, interc.	-5.66***
CZE	no	-1.778**	2005Q1, both	-5.52**	no	-2.365**	no	-1.528*
HUN	no	-1.897**	2007Q1, interc.	-4.449*	no	-3.029***	no	-1.615**
POL	no	-1.331*	2005Q3, both	-5.023**	no	-2.729***	no	-3.114***
ROU	no	-3.539***	2008Q1, interc.	-5.342***	no	-2.372**	no	-2.999***
SVK	no	-2.561***	2008Q1, interc.	-4.625*	no	-2.386**	no	-2.679***
SVN	no	-2.372**	2008Q2, both	-4.778*	no	-2.527***	no	-0.685

Note: ZA test reported if break exists, otherwise ADF is reported

Levels of significance: * p<0.1, ** p<0.05, *** p<0.01

Source: *own calculations*

Results of unit root tests show that most of the variables are stationary at least at 0.1 level of significance. The exceptions are inflation rates for Bulgaria and Slovenia, where the ADF test failed to reject the null. Yet, only two isolated cases are not regarded as a matter of particular concern for the general reliability of the VAR estimations. The ZE test properly identifies time points in which breaks occurred, most of them being inside crisis window.

6.4.3 Estimation results

The lag order in the VAR is typically determined endogenously according to some information criterion (Akaike, Swartz). Yet, having a limited number of observations per time-series (33 for Croatia and 52 for other countries in the sample), we opt for the second lag order of VAR to preserve the degrees of freedom. In that case, each equation in the VAR contains nine unknown parameters. Here we report only the R-squared coefficients of single equations across countries (Table 6.13).

Table 6.13: Explanatory power of estimated VAR models

Country	r_t	rg_t^p	Δfx_t	π_t
BGR	0.82	0.92	0.78	0.90
HRV	0.64	0.99	0.80	0.97
CZE	0.89	0.98	0.82	0.94
HUN	0.98	0.93	0.69	0.91
POL	0.95	0.92	0.73	0.88
ROU	0.93	0.94	0.76	0.99
SVK	0.92	0.96	0.88	0.94
SVN	0.98	0.98	0.70	0.98
Average	0.89	0.95	0.77	0.94

Source: *own calculations*

The explanatory power of the estimated VAR equations is considerably high, never falling below 64% (case of Croatian interest rate). Considering the simple average of R-squared across equations, change in real effective exchange rate and implied interest rate seems to be slightly less explained by the estimated VAR(2) models, while share of explained variations in potential real growth and inflation are a bit higher reaching 95%.

I proceed with the forecasting exercise as follows. First, I specify the scenarios and calibrate the inputs. Then, I compute the point forecasts and compare them to benchmark actual values.

Scenario setup and FRF calibration

As discussed in the previous chapters, the DSA analysis typically starts with the definition of a baseline scenario and several alternative scenarios of macroeconomic development. In our VAR-FRF framework, the dynamics of non-fiscal variables are endogenously determined by the VAR forecasting outcomes, so that discrete scenarios are limited to cyclically-adjusted primary balance, which is indeed the most exogenous determinant of public debt. Baseline and alternative scenarios are specified by calibrating the pre-determined and random components of FRF as

$$capb_{i,T+h} = \Gamma_{i,T+h} + \beta d_{i,T+h-1} + \gamma og_{i,T+h} + \varepsilon_{i,T+h};$$
$$\Gamma_{i,T+h} = \mathrm{X}_{\mathrm{i,T+}h}\theta + \lambda_{i,T+h}$$

This effectively means that FRF inputs $\Gamma_{i,T+h}$, $\lambda_{i,T+h}$ and $\varepsilon_{i,T+h}$ need to be calibrated. I saw in the FRF estimation results that effects of control variables $\mathrm{X}_{\mathrm{i,T+}h}$ do not play an important role in determining the balance, so there is no need to make dynamic calibration of this input. Instead, I suppose that it is fixed and equal to the historical average of $\Gamma_{i,t}$ obtained from the FRF estimation for each country in the sample. In a similar fashion, I suppose that random shock $\varepsilon_{i,T+h}$ follows the normal distribution $\varepsilon_{i,t} \sim N\left(0, \hat{\sigma}^2_{\varepsilon_i}\right)$ in the Monte Carlo simulations, whereas $\hat{\sigma}^2_{\varepsilon_i}$ is estimated from the FRF country-specific regression residuals. Calibration of future fiscal policy actions is more peculiar, being a forward-looking concept that cannot be determined based on historical data. To preserve the notion of generality in the analysis, I prefer to use the country-specific recommendations from the European Commission on fiscal policy available in 2012, rather than look for the policy actions into country-specific fiscal policy documents. As previously mentioned, the EEC countries were subject to Excessive Deficit Procedure (EDP) due to their high deficits (mostly) in the aftermath of the global financial crisis. Proposed measures before 2013 by the EC to reduce deficits are summarized in Table 6.14.

Table 6.14: Excessive deficit procedure in EEC

Country	EDP launched	EDP abrogated	Proposed measures of deficit reduction
BGR	06.07.2010	22.06.2012	at least 0.75 pp
HRV	10.12.2013	12.06.2017	Not applicable
CZE	11.11.2009	20.06.2014	1pp
HUN	24.06.2004	21.06.2013	1pp
POL	24.06.2009	19.06.2015	1.25pp
ROU	24.06.2009	21.06.2013	1.25pp
SVK	11.11.2009	20.06.2014	1 pp
SVN	11.11.2009	17.06.2016	0.75pp

Source: *European Commission website*

Most of the EDP were abrogated during the forecast period, except for Croatia, where the EDP was launched in 2013. Size of the proposed reduction of deficit during the EDP averaged 1 percentage point of GDP, and therefore I calibrate $\lambda_{i,T+h}$ to be equal to that number. Note that Bulgaria, Romania and Hungary were already on the EDP exit by the end of 2012. In these cases, I calibrate $\lambda_{i,T+h}$ to be equal to zero. In case of Croatia, I set it also to zero, because the country was not an EU member in 2012.

Described calibrations of $\Gamma_{i,T+h}$, $\varepsilon_{i,t}$ and $\lambda_{i,T+h}$ together with the estimated regression coefficients β and γ from the FRF full-sample regression represent the set of baseline scenario inputs. I use the regression coefficients obtained by AB estimator, being arguably more reliable than FE or IV options. The two alternative scenarios consider pure pro-cyclical fiscal response (β restricted to zero) and pure debt-stabilizing fiscal response (γ restricted to zero). Being aware of the uniqueness of the analyzed period related to strong economic cyclicality, I also prefer using the coefficients from the full-sample FRF rather than good times/bad times estimation in the alternative scenarios. Indeed, the response of the primary balance to debt in bad times is close to 0.1. Such estimate can produce oversized forecasts of fiscal response to debt in countries where public debt-to-GDP ratio is relatively high.

Finally, the estimation of the fiscal response requires contemporaneous values of real output gap, which are not produced by the VAR forecasts. A possible solution is to substitute the potential with the actual real growth rate, use the forecasted actual rates to project real GDP, and then filter it using HP to get potential real GDP. However, fiscal policy decisions are rather driven by forward looking growth expectations, so I decide to use GDP forecasts instead of the historical-based estimations. To this end, I use the IMF

World Economic Outlook forecasts of GDP being representative source of mainstream growth expectations, available by the end of 2012 to keep the consistency with the forecasting strategy. These forecasts (Table 6.15) are available only in annual frequency, but I assume constant annualized quarterly growth rates equal to annual forecast.

Table 6.15: The IMF real growth forecasts in 2012

	2013	**2014**	**2015**	**2016**
BGR	1.500	2.500	3.500	4.500
HRV	0.953	1.500	2.000	2.500
CZE	0.785	2.801	3.411	3.409
HUN	0.797	1.553	1.651	1.706
POL	2.050	2.716	3.108	3.428
ROU	2.476	3.005	3.316	3.519
SVK	2.800	3.600	3.600	3.600
SVN	-0.358	1.713	2.080	2.303

Source*: the WEO, October 2012*

6.4.4. Point forecasts

Point forecasts typically represent the output of deterministic forecasting such as the IMF DSA methodology. They describe the central tendency of the variable dynamics without the information about the confidence interval. In this section, I provide a country-overview of public debt point forecasts and their out-of-sample performance in the medium run. To this end, I use ESA 2010 time-series of actual public debt and the IMF forecasts by the end of 2012 as the comparison benchmark. The evolution of public debt up to last quarter in 2016 is presented in Figure 6.6.

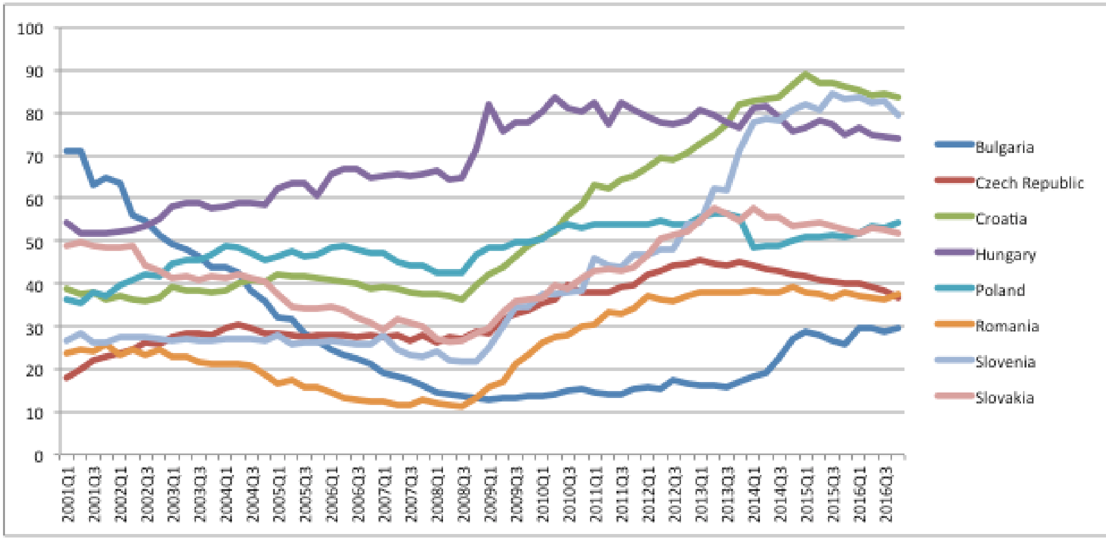


Figure 6.6: Public debt in EEC (% of GDP), 2001-2016

Source: *ECB Data warehouse, retrieved in July 2017*

When the global financial crisis broke out, most EECs experienced a rise in deficits and debts. The amount of public debt relative to GDP stabilized without endangering the fiscal solvency. However, it remained relatively high in some countries. The main purpose of comparing the medium-run forecasts to the actual data is to assess whether the central tendency of forecasted public dynamics has been confirmed by the trends in the actual data. Additionally, the IMF forecasts (Table 6.16) are included to assess the accuracy of the model forecasts.

Table 6.16: the IMF public debt forecasts in 2012

	2013	**2014**	**2015**	**2016**
BGR	16.38	18.40	15.26	13.63
HRV	57.02	59.43	61.29	62.66
CZE	44.96	45.63	45.74	45.72
HUN	74.24	75.35	75.86	76.32
POL	55.34	55.05	54.61	53.43
ROU	34.46	33.69	32.90	32.09
SVK	47.22	47.63	48.05	48.38
SVN	57.45	58.69	59.22	59.13

Source: *the WEO, October 2012*

I produce point forecasts of public debt up to 2016 for each country under the baseline (denoted B), pro-cyclical (denoted A1) and debt-stabilizing (denoted A2) scenarios. It turns out that, due to the narrow output gaps in observed forecasting period, baseline and A2 scenarios produce very close values. Therefore, I do not report the A2 scenario in the medium-run analysis. It is also important to mention that I smoothed the forecasted values using moving averages to emphasize the tendency of dynamic evolution. I roughly categorized the eight point forecasts to those being “more” accurate (Figure 6.7) and those being “less” accurate (Figure 6.8). No formal criterion is applied to rank the accuracy of the forecasts, but a simple visual match with the actual data and with the IMF forecasts.

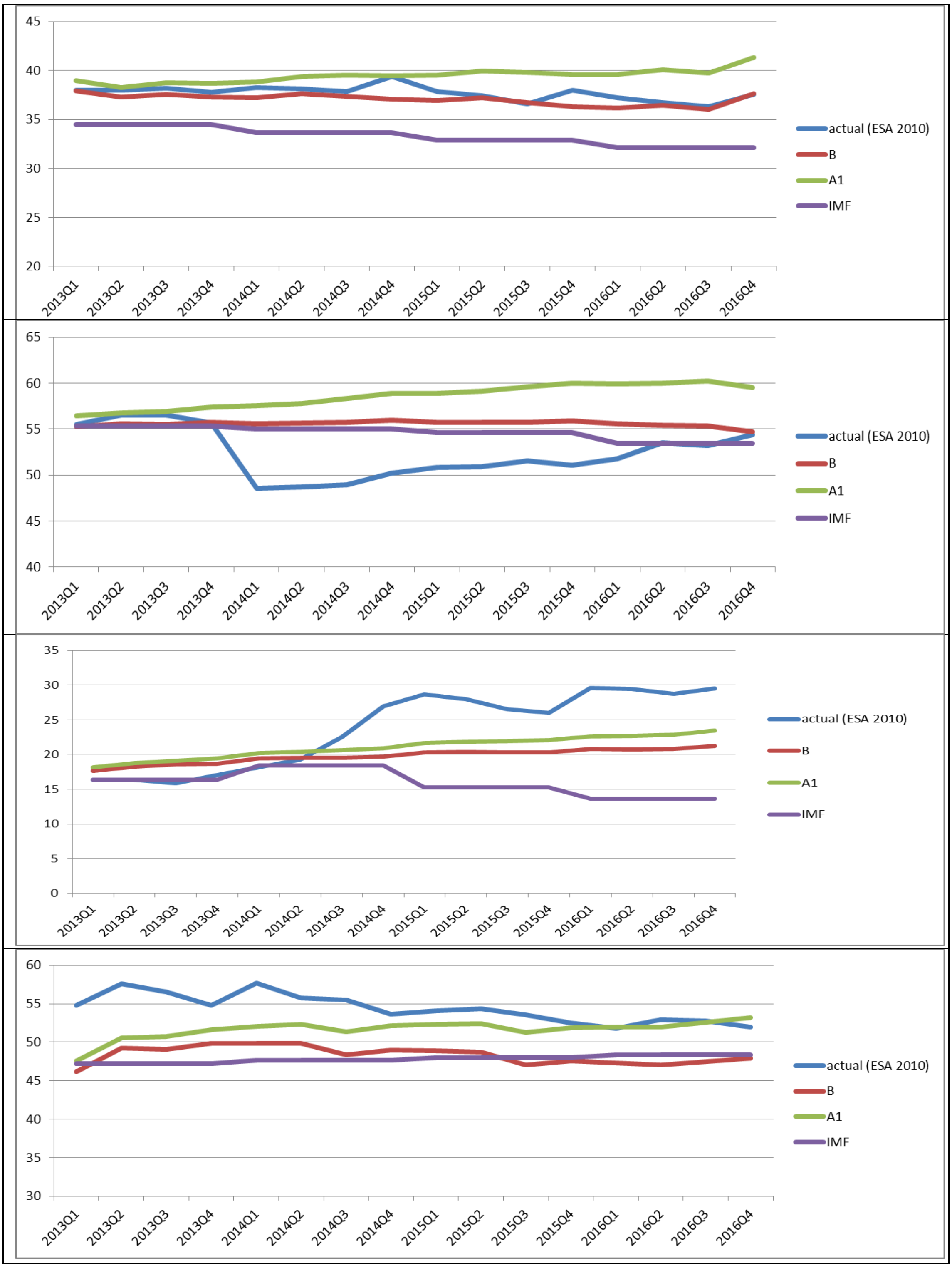


Figure 6.7: “More” accurate model point forecasts (Romania, Poland, Bulgaria, Slovak R)

Source: *own calculation*

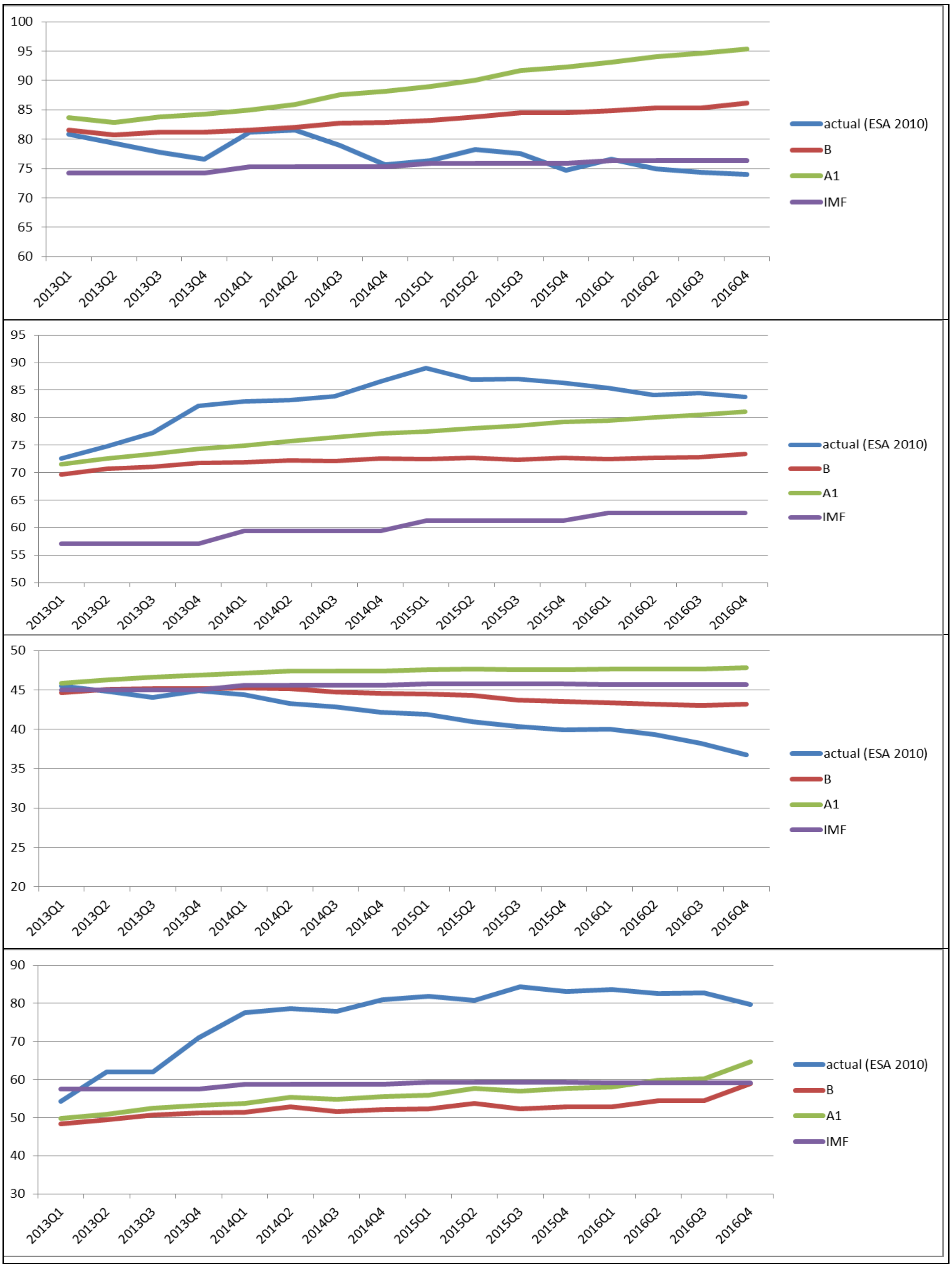


Figure 6.8: “Less” accurate model point forecasts (Hungary, Croatia, Czech, Slovenia)

Source: *own calculation*

The first thing to notice is that A1 scenario always produces higher public debt forecasts than the baseline, so it can be characterized as a risky scenario of debt-neglecting fiscal reaction. Secondly, both IMF and our forecasts fail to match closely the actual values of public debt, indicating that impact of debt-deficit adjustments on debt dynamic was high after 2012, too. Third, the forecasted value of public debt from either baseline or A1 scenario tends to slightly increase over horizon, the case of Poland being an exception. Fourth, discrepancy between actual and forecasted values tends to increase over the forecasting horizon, but not necessarily; for example, in case of Poland it narrows over time. Furthermore, the model forecasts are at least as accurate in levels as the IMF benchmark, except in case of Hungary. Even in the group of less accurate forecasts, the divergence between model forecasts and the actual debt levels never gets dramatically high. The exception is Hungary, where there is an obvious and growing divergence between the forecasted debt and the actual debt dynamics. Bottom line, none of the forecasted debt dynamics in the EECs signals unsustainable debt paths and potential insolvencies in the medium run.

Debt sustainability assessment using stochastic debt simulations

In this section, I combine stochastic debt simulations with the key concepts in conducting a more explicit analysis of debt sustainability assessment, the stress testing and the debt threshold. The notion of the stress testing in deterministic DSA is already discussed. The alternative scenarios are typically applied to assess the public debt dynamics assuming some moderate changes in macroeconomic environment or policy reactions. On the other hand, the stress testing captures the effects of extremely unfavorable moves in macroeconomic variables on future debt trajectories, which are more likely to seriously deteriorate the fiscal solvency and trigger a default.

6.4.5 Stochastic forecasts

A point forecast indicates the most likely public debt trajectory, but does not indicate the risk of debt being higher or lower than the expected value. Deterministic stress testing provides some extremely detrimental debt trajectories, but does not report probability of their occurrence. In the context of stochastic dynamic forecasting, point forecast of a given variable is usually accompanied with upper and lower bands of interval confidence that capture 95% of the possible forecast realizations. Such approach is not suitable in the case of our VAR-FRF forecasting framework, which combines the two sources of uncertainty, non-fiscal and fiscal shocks. Monte Carlo simulations are plausible solution to overcome this issue and produce a distribution of possible debt outcomes across the forecast horizon. I run 10,000 simulations using the VAR-FRF framework to produce probability distribution of debt outcomes for each country, for both baseline and A1 scenario. Simulations are computed in Matlab R2012b, and the Matlab code is supplied in Appendix B. The outcomes of the simulation are presented in the figures 6.9 – 6.16.

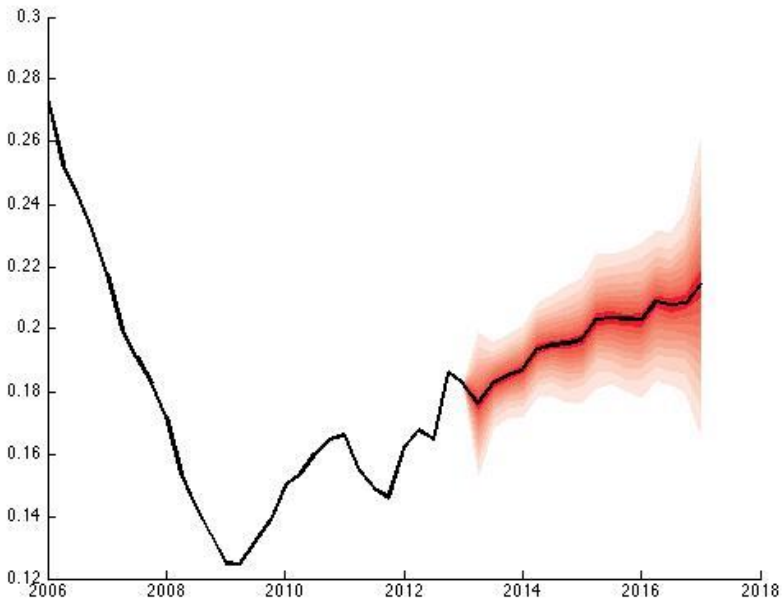


Figure 6.9a BGR, Stochastic forecast of public debt, baseline scenario
Source: *own calculation*

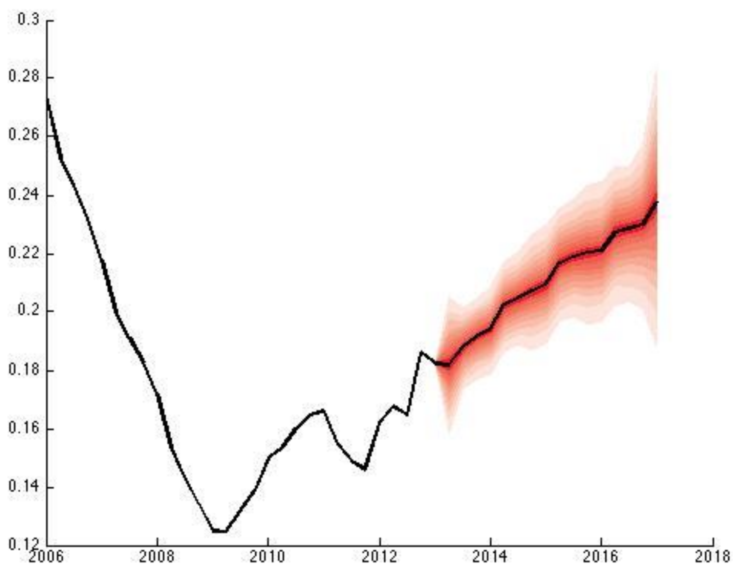


Figure 6.9b: BGR, Stochastic forecast of public debt, alternative scenario
Source: *own calculation*

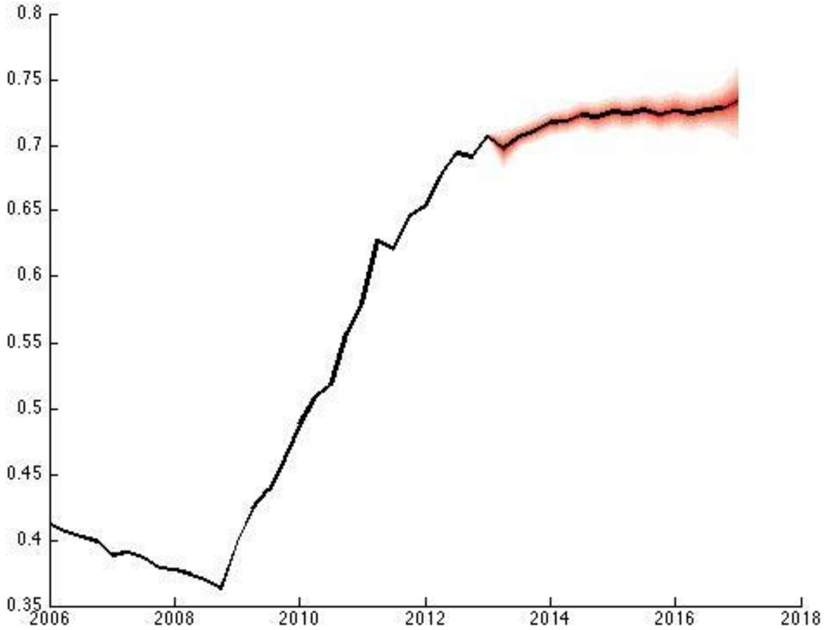


Figure 6.10a HRV, Stochastic forecast of public debt, baseline scenario

Source: *own calculation*

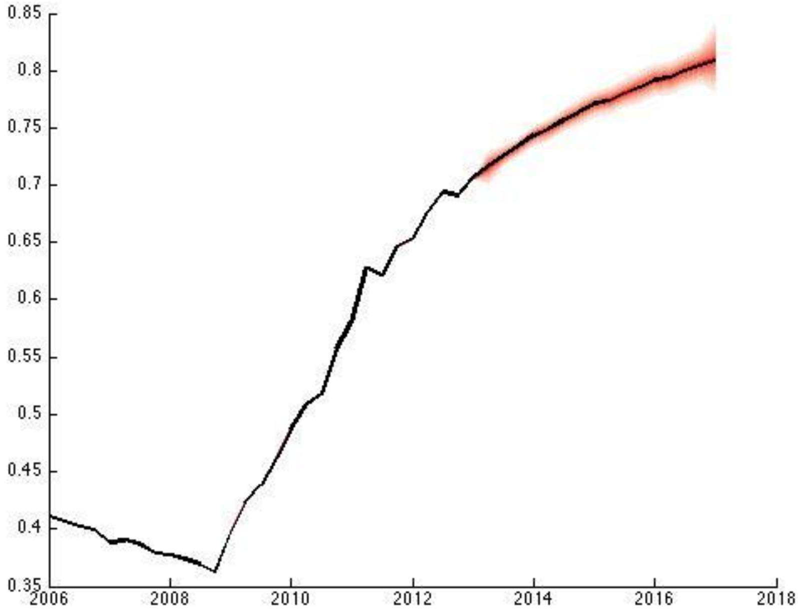


Figure 6.10b HRV, Stochastic forecast of public debt, alternative scenario

Source: *own calculation*

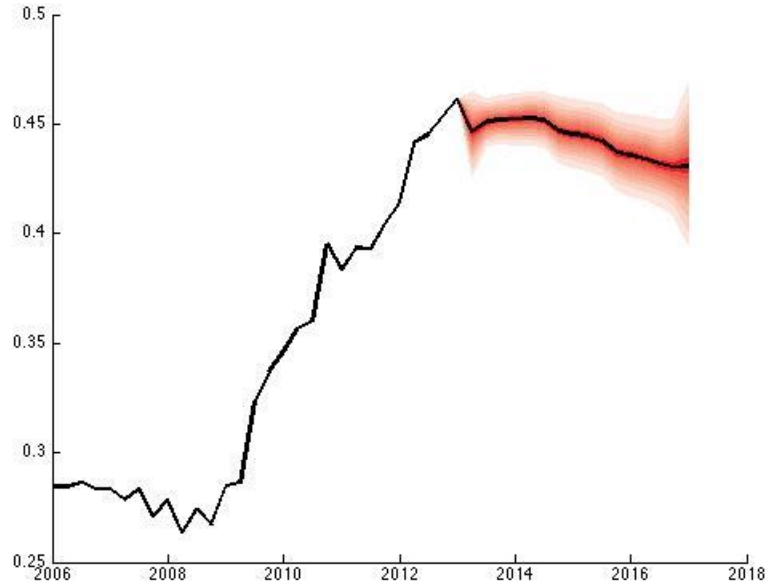


Figure 6.11a CZE, Stochastic forecast of public debt, baseline scenario

Source: *own calculation*

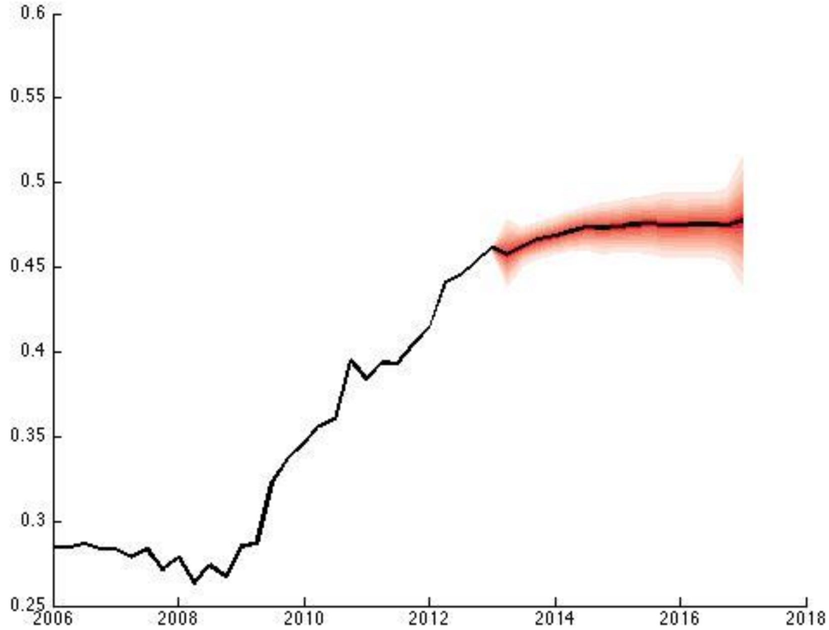


Figure 6.11b CZE, Stochastic forecast of public debt, alternative scenario

Source: *own calculation*

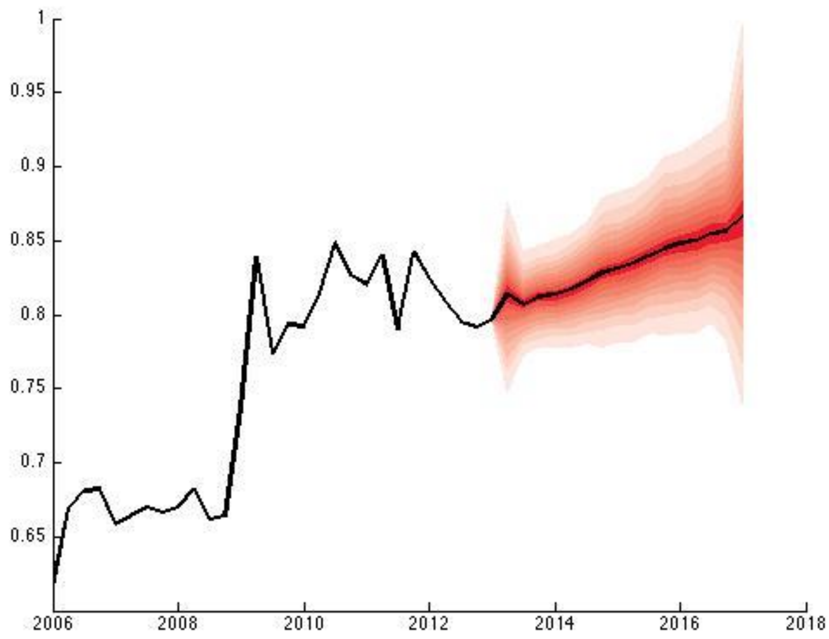


Figure 6.12a HUN, Stochastic forecast of public debt, baseline scenario

Source: *own calculation*

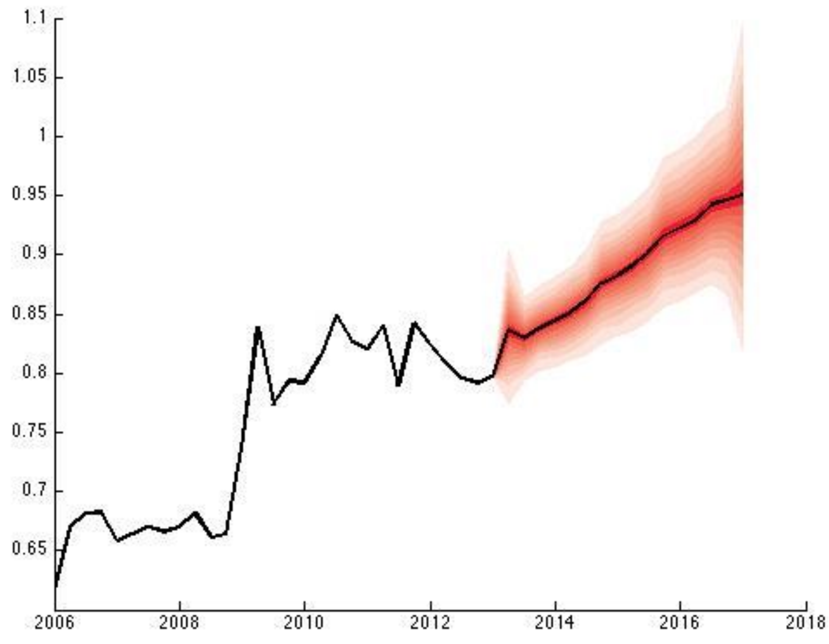


Figure 6.12b HUN, Stochastic forecast of public debt, alternative scenario

Source: *own calculation*

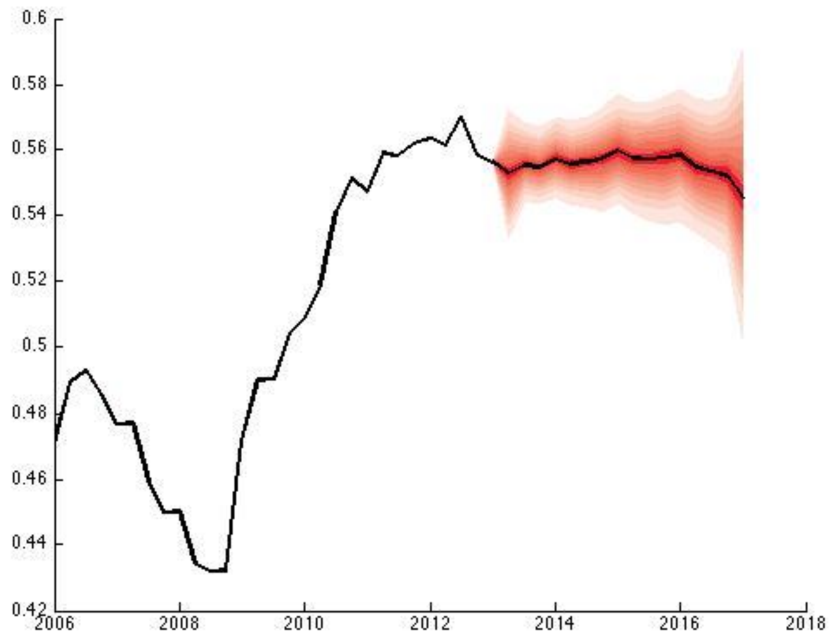


Figure 6.14a POL, Stochastic forecast of public debt, baseline scenario
Source: *own calculation*

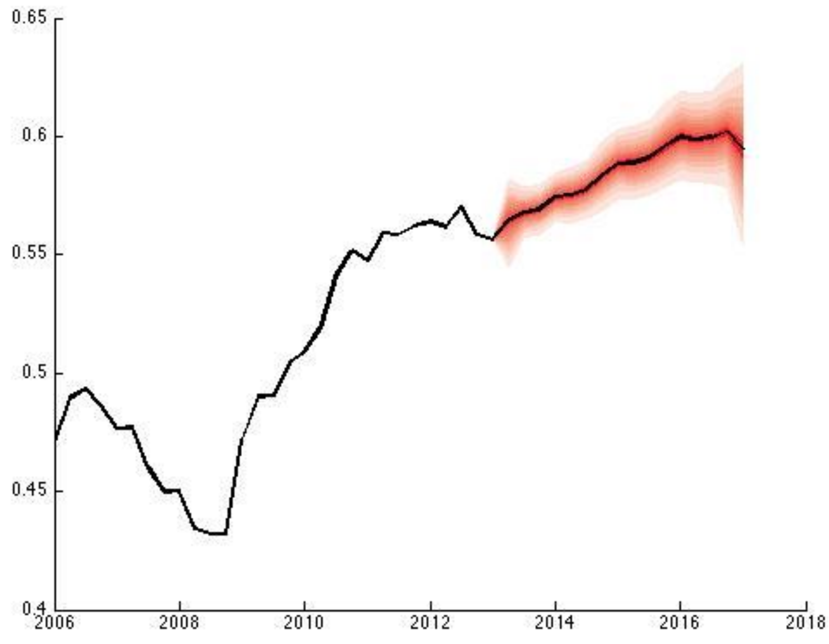


Figure 6.14b POL, Stochastic forecast of public debt, alternative scenario
Source: *own calculation*

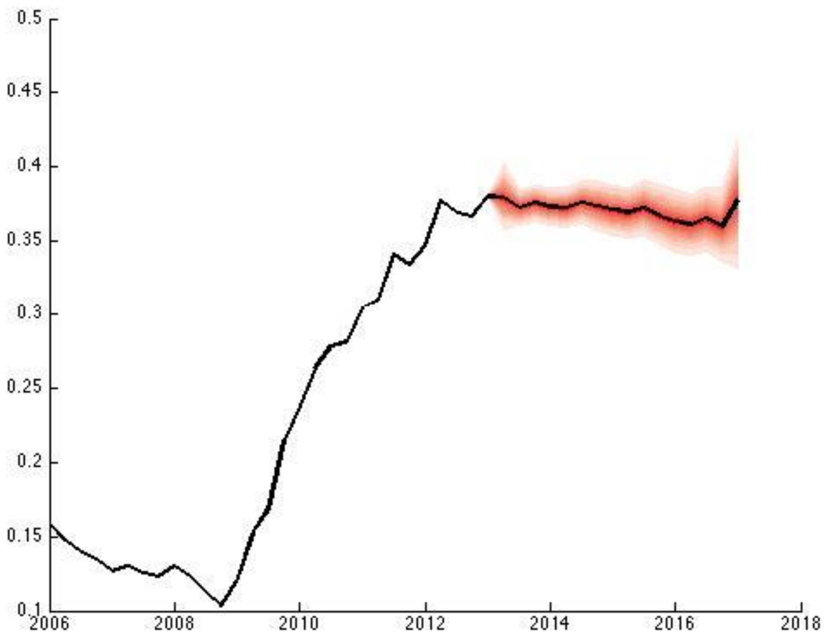


Figure 6.14a ROU, Stochastic forecast of public debt, baseline scenario

Source: *own calculation*

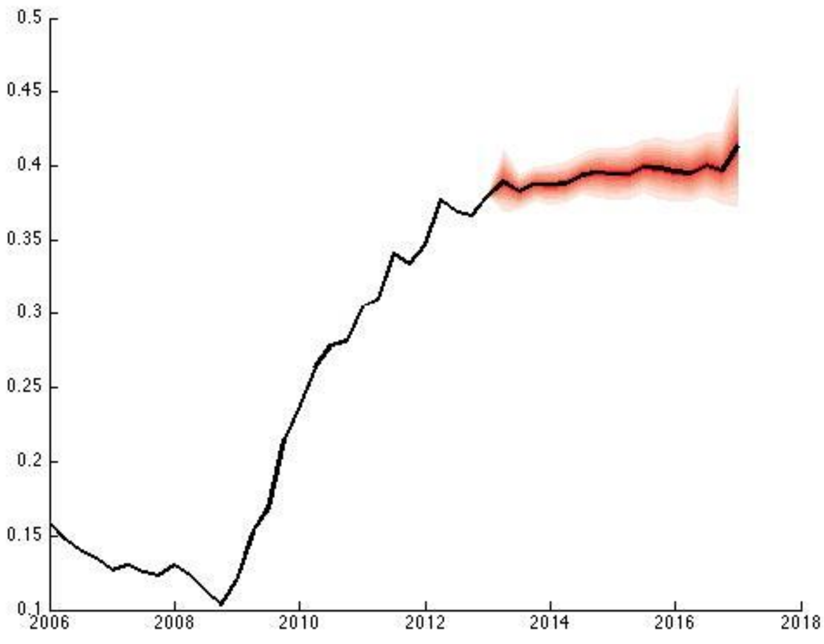


Figure 6.14b ROU, Stochastic forecast of public debt, alternative scenario

Source: *own calculation*

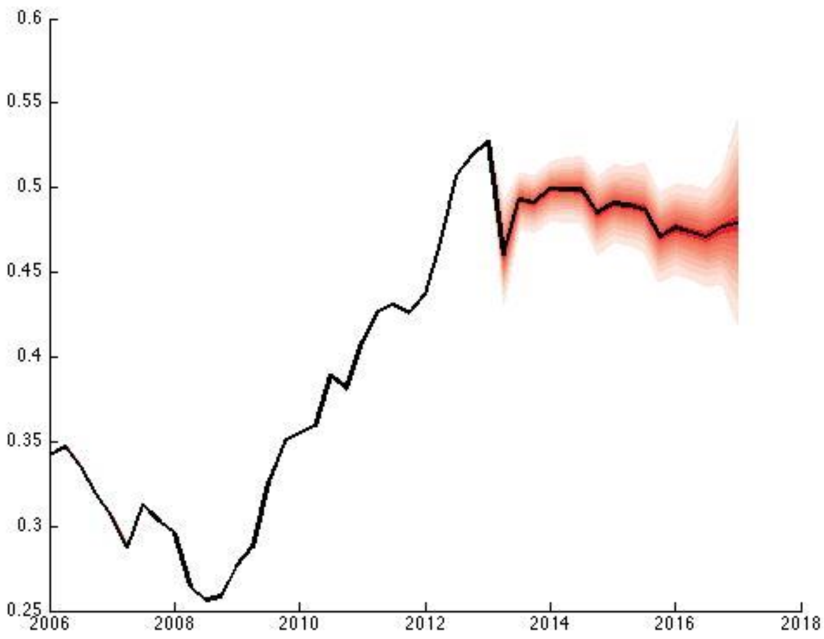


Figure 6.15a SVK, Stochastic forecast of public debt, baseline scenario
Source: *own calculation*

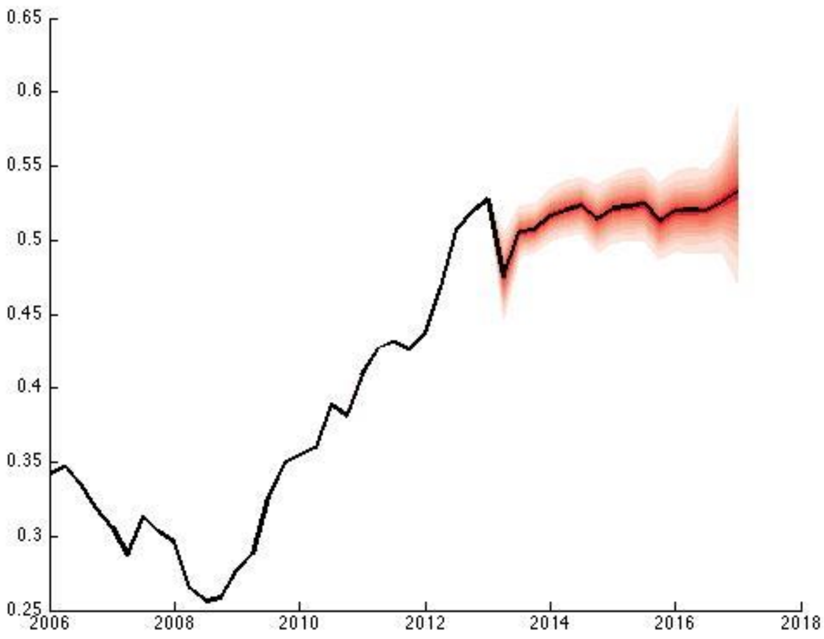


Figure 6.15b SVK, Stochastic forecast of public debt, alternative scenario
Source: *own calculation*

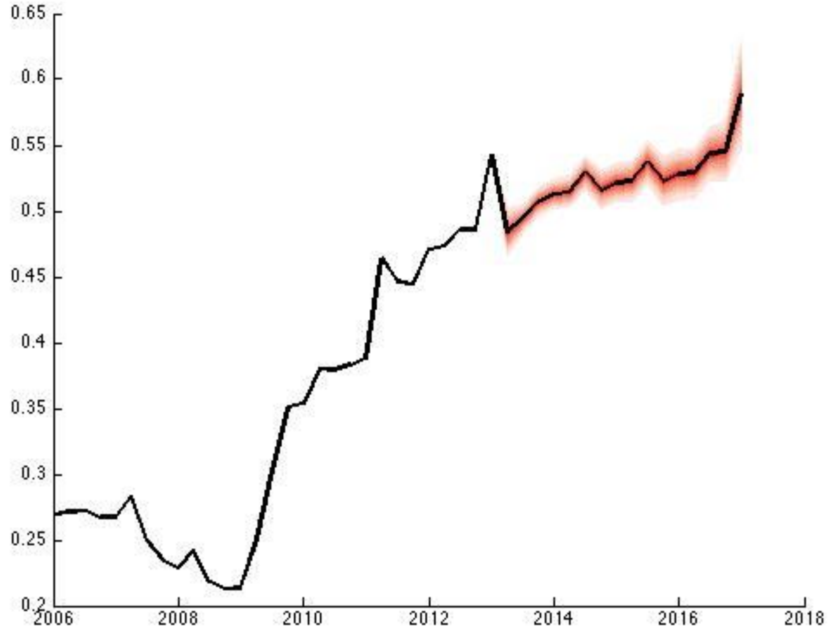


Figure 6.16a SVN, Stochastic forecast of public debt, baseline scenario
Source: *own calculation*

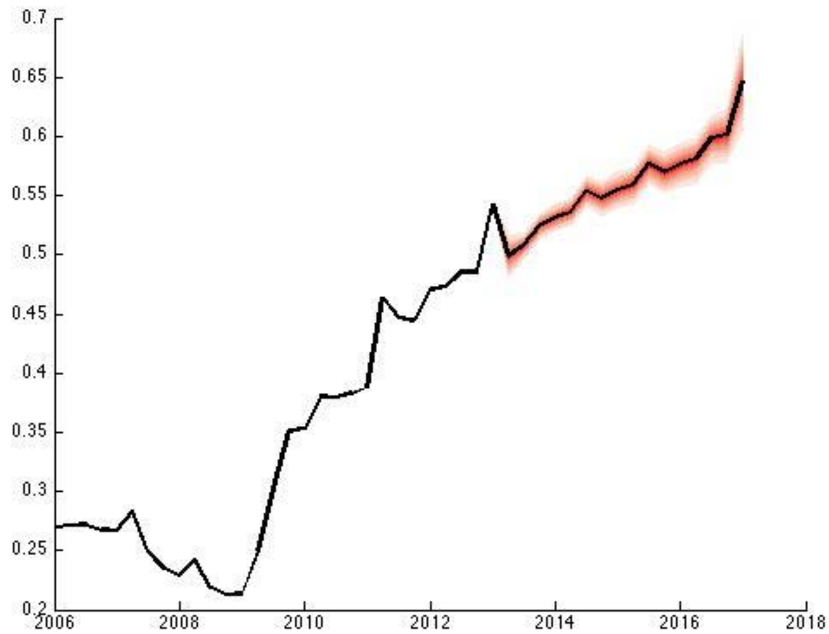


Figure 6.16b SVN, Stochastic forecast of public debt, alternative scenario
Source: *own calculation*

Fan charts are popular way to present the probabilistic properties of simulated random outcomes, as they provide an intuitive depiction of probability density function. At the same time, the simulations provide an indirect stress testing, as the outcome values in the highest quintile describe the most extreme debt trajectories forecasted by the model, which probability of realization is less than 5 per cent. As both non-fiscal and fiscal shocks are drawn from normal distribution, density function of debt outcome is also bell-shaped. In set of our figures it is a bit distorted at the beginning and ending of forecast period, due to the smoothing of the forecasted debt trajectories.

The range of simulated debt trajectories across countries is relatively narrow, roughly 5 percentage points above and below the median. To assess the country-by-country debt sustainability (as in Eller & Urvova, 2012), I compare the simulated debt forecasts to the assumed 60% debt-to-GDP ratio being generic threshold for the emerging countries (and the Maastricht criterion, too).

1. Bulgaria: debt is stable and considerably lower than the threshold under any constellations of shocks and scenarios – low risk of unsustainability;
2. Croatia: debt-to-GDP exceeded 60% even at the start of forecasting period with tendency of further growth – high risk of unsustainable debt;
3. Czech Republic: under some constellation of shocks and scenarios debt-to-GDP can come close to the threshold, but risk is estimated to be low;
4. Hungary: debt-to-GDP was already far above the threshold and under some constellation of shocks and A1 scenario even can come close to 100% - high risk of unsustainability;
5. Poland: debt-to-GDP exceeded the threshold in risky scenario, but remained close to 60% - moderate risk of unsustainability;
6. Romania: debt is stable and lower than the threshold under any constellations of shocks and scenarios – low risk of unsustainability;
7. Slovak Republic: debt-to-GDP has may come very close to the threshold, but even in case of the most extreme outcomes remains lower than 60% - moderate risk of unsustainability;
8. Slovenia: debt-to-GDP tends to steadily increase over the 60% threshold – moderate risk of unsustainability.

I also compare our results to the work of Eller & Urvova (2012), see Figure 4.12. They provide a DSA under the similar VAR-FRF approach to produce stochastic simulations of debt paths in a 5-year forecasting period from 2011 to 2016, but limit their scope of countries only to Czech Republic, Hungary, Poland and Slovak Republic. I compare the outcomes of baseline scenarios only.

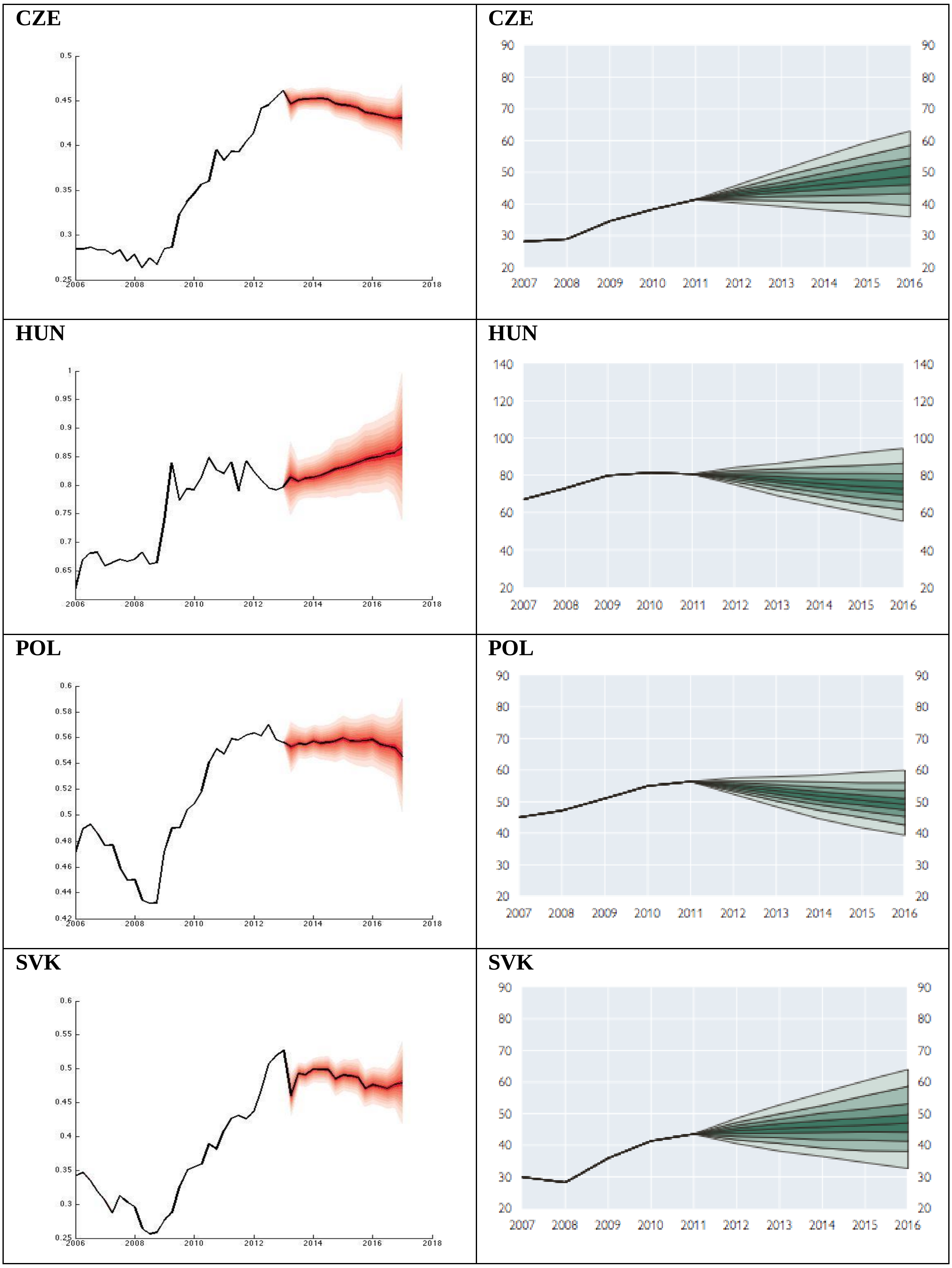


Figure 6.17 – Comparison of our results with Eller & Urvova (2012)
Source: *own calculation and Eller & Urvova (2012)*

The forecasted debt trajectories in Eller & Urvova (2012) seem to be close to the median values of our simulations. Nevertheless, the distributions of possible outcomes in Eller & Urvova (2012) are considerably wider. The difference is most likely given by the different methods of FRF estimation: in the case of Eller & Urvova (2012), the estimated residuals from the FRF regression seem to produce higher values of country-specific standard deviations and consequently higher values of calibrated fiscal shock.

Summarizing all the results of the from the FRF estimation and debt dynamics forecasting using VAR-FRF framework, three exceptionally important conclusions can be emphasized:

1. There is no evidence that stochastic VAR-FRF estimation outperforms deterministic approach used by the IMF. Out-of-sample analysis indicates single-point baseline forecasts made by the stochastic VAR-FRF are very close to the IMF baseline. Consequently, only in three out of eight considered cases VAR-FRF forecasts clearly outperformed those of the IMF.

2. Primary balance is found to respond positively to the lagged government debt, and response seems to be stable regardless of structural adjustment. According to standard interpretation of model-based fiscal policy assessment, this is seen as an evidence of responsible behavior of EEC governments with respect to its inter-temporal budget constraint. However, additional analysis reveals that positive response of balance to lagged debt may be weaker than it seems at the first glance. Good and bad times analysis suggests that cyclically-adjusted primary and overall balance reacted positively to debt only after the crisis outbreak. This finding confirms validity of the hypothesis H3, that positive response of primary balance to accumulated debt is indeed condition for maintaining fiscal sustainability

3. Direct comparison of the projected public debt dynamics under the baseline scenario and scenario of the pro-cyclical response for the EEC 8 sample clearly demonstrates that pro-cyclical response of the primary balance leads to a considerably higher levels of debt-to-GDP ratio relative to baseline forecasts. Except for Bulgaria wherein public indebtedness is apparently, difference between single point forecasts of pro-cyclical and baseline scenario at the end of forecasting period ranges between five to ten percentage points. In addition, confidence interval of the debt forecasts obtained under A1 is apparently narrower than in case of baseline.

7. CONCLUSIONS

7.1 Main research results

By the end of the first decade of the 21st century, many small open economies have experienced spillovers from one of the worst crises that ever hit economic activity on the global level. One of the most important lessons which have been learned in the aftermath of the crisis is that records of macroeconomic variables' actual values may not be the best choice of fiscal policy metrics in times of sizable economic fluctuations.

The Emerging European Countries were among those that were most heavily damaged since their strong economic momentum was suddenly interrupted and reversed down to the point of recession. Stylized facts on cyclicality and indebtedness of EEC clearly illustrate that point: prior to crisis, public debt was on the path of decline, but declining trend abruptly overturned whereas policymakers were struggling to recover economic growth by means of fiscal and monetary policy. Eventually, low initial values of the public debt in EEC relative to their advanced counterparts saved the day; precautionary Excessive Deficit Procedure was launched in most of EEC EU member states and it seems that fiscal sustainability has restored in the region after days of recession have been gone.

Disguised fiscal vulnerabilities in EEC were disclosed shortly after the crisis outbreak, and actual macroeconomic records prior to the crisis have to be blamed for a blurred image of real fiscal conditions. With this reflection in mind, this thesis put a serious attempt to shift the paradigm of making fiscal policy decisions toward application of the structural fiscal metrics. To this end, standard methodological approach of VAR-FRF based public debt modeling and forecasting is adjusted to reflect structural or at least cyclically-adjusted indebtedness rather than actually observed. The introduction of the version of VAR-FRF stochastic framework based on potential GDP and structural fiscal stance represents the most important result in terms of contribution to the fiscal sustainability assessment.

The empirical research is mostly organized to follow research hypotheses Descriptive analysis of debt decomposition for EEC 8 (including Serbia) imposes that debt-deficit adjustments and CA primary balance as the fiscal variables are the most important contributors of public debt dynamics. Up to my best knowledge, specification of the regression model that empirically estimate the impact of the debt determinants on the dynamics of public indebtedness was not use in existing empirical studies. The results of both descriptive and econometric analysis on relations between debt and its determinants provide enough evidence in favor of H1 and H2 acceptance. Yet, it is also important to mention that validity of H2 holds with no ambiguity only in case when change in structural indebtedness is dependent variable, which is another result in support of appropriateness to use structural measure of fiscal stance in debt sustainability analysis.

The estimation of the FRF using CAPB is also one of the oddities of research in this thesis since most of the comparable research use actual primary balance values. The findings that after cyclical adjustment reaction of primary balance to output gape turns to be strongly pro-cyclical is regarded as valuable empirical result Good and bad time analysis shows that pro-cyclicality is emphasized in good times when output gaps are positive, though in bad times response is a-cyclical. Eventually, the combined results of the empirical analysis related to the VAR-FRF framework of fiscal sustainability assessment supported the validity of the H3 and H4 hypotheses.

Beside empirical results that are utilized for the research hypotheses testing, out-of-sample exercise give profound overall value added to empirical research in this thesis, being the first of such type up to my best knowledge. The lack of evidence that methodological complexity of VAR-FRF modeling does not bring expected value added in terms of forecasting accuracy (at least for the given countries and time covered by the sample), in support of the contemplation of Adams et al. (2010) that "*it is frequently argued that fiscal sustainability analysis is more of an art than a science*". In light of VAR-FRF failure, simple deterministic approach such as MTDS cost-risk analysis that has been applied in case of Serbia may provide more reliable results, at least because it utilizes information about public debt portfolio structure.

7.2 Research implications to fiscal policy

Despite tremendous advances in statistics, econometrics, financial engineering, computational sciences and IT solutions, the global crisis was an ultimate surprise. The bottom line of the out-of-sample empirical analysis in this thesis can be interpreted in terms of very trivial common knowledge - the future is very hard to predict, despite all methodological and technical advances in forecasting practice. Following this remark, instead of speeding up the pace of development toward more and more complex analytical frameworks, policymakers can be better off by simply putting more focus on what turns to be crucial for the still-standing during the bad times, that is minimizing risk exposures by minimizing macroeconomic and fiscal vulnerabilities. More specifically, several recommendations on precautionary activities to fiscal policymakers are suggested:

Targeting structural values of balance and its components. Empirical findings in this thesis illustrated that overwhelming reliance on the fiscal policy on actual values can be quite misleading, especially when cyclicality of balance response is regarded. While computing structural balances with respect to cycle, beyond-the-cycle and one-offs in standardized manner for a panel of countries can be profoundly challenging tasks, country-specific estimations are more likely achievable tasks for the fiscal authorities due to greater data availability and better insight in national practices of creative public accounting. Thus, governments are recommended to regularly appraise and project structural fiscal indicators in regard to different scenarios of macroeconomic forecasts and give more weight to such indicators in designing the long-term fiscal policy targets.

Application of fiscal rules to structural targets. The application of fiscal rules to actual values of budget components may not always be a good solution. Koen and Nord (2005) provide evidence that even advanced countries, when faced more binding fiscal rules, tend to exploit one-offs and creative accounting to create fiscal gimmicks. Similar results are presented by Frankel (2011a), who finds that if country is subject to a fiscal rule (like SGP) official forecasts tend to be more biased and more pro-cyclical. Coricelli and Ercolani (2002) also noted that application of SGP criterion for budget deficit is not appropriate for new EU member states with pro-cyclical fiscal stance and proposes modified rule based on structural deficit. According to Frankel (2011b), Chile was the first country that uses structural deficit as target (corrected for copper which is Chile' main export product) to fight pro-cyclicality and it has shown as highly successful strategy. Indeed, research of Bova et al. (2014) provides empirical evidence that targeting a cyclically-adjusted balance as opposed to the headline balance tends to improve the stabilizing properties of the rule in emerging economies.

Greater reliance on the early warning vulnerability indicators. Vulnerabilities in private sector like absorption booms and asset price bubbles result in large temporary components of budget items, especially on the revenue side. Thus, indicator that tracks differences between standard cyclically-adjusted balance and structural balance can be useful tool for early warning that some beyond-the-cycle factor is affecting fiscal stance.

Making the public familiar with the idea of the concept counter-cyclical policy. As mentioned, the public typically makes judgments on effectiveness of the fiscal policy based on actual values of macroeconomic variables and often does not understand notion of structural values and necessity of counter-cyclical policy. The government may use means of public information to advocate successful stories of counter-cyclical policies, like case of Chile (Frankel, 2011b), to avoid loss of rating in good times.

7.3 Limitations and recommendations for further research

The most important limitations of the research are stemming from not addressing other drawbacks identified in the review of the existing literature, apart from the out-of-sample performance. This also imposes some directions for future research:

Substantial redefining of the SVAR identification. Since SVAR modeling is added into the IMF DSA methodology, Cholesky decomposition has been routinely applied as an SVAR identification scheme, with the arbitrary ordering of the variables. The introduction of some identification schemes based on the theoretical ground may the good start in improving effectiveness of the VAR-FRF forecasting framework.

Use of alternative VAR specifications. As in the previous case, almost all applications of VAR-FRF framework in empirical analysis of the debt sustainability uses the same specification of the VAR model. More particularly, VAR specification only consists of the debt determinants. Empirical experimenting with some alternative VAR specifications may turn to be beneficial for the strengthening of the forecasting power.

Novel approach to fiscal sustainability assessment based on endogenously determined country-specific debt threshold. The basic VAR-FRF analytical framework is only capable of producing stochastic simulations of the possible debt paths under macroeconomic shocks. The only way to explicitly compute default probabilities will require the use of some arbitrarily chosen debt threshold, like 60% Maastricht criterion. Yet, one-size-fits-all approach may not be the best solution and introduction of country-specific debt threshold will be important methodological advance.

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Appendixes

Appendix A: Data description and sources

According to existing regulation (Council Regulation 479/2009), EU member states are obliged to report so-called the EDP notification tables twice per year (31 March and 30 September to the European Commission, which is in charge of collecting and providing data to European Council for the Excessive Deficit Procedure. The EDP notification tables consist the data on actual and planned deficits, level of government debt, and also the link between net lending/borrowing (i.e. deficit) and change of public debt.

Data on public debt of EU member states included in our sample are mostly available on quarterly and annual levels. I use the European Central Bank as a primary source of data on public debt and other relevant government balance items, due to the comprehensiveness of coverage of government finance statistics obtained by the centralization of collected data from the other sources (National Central Banks, National Statistical Institutes, Eurostat)[37]. Basically, two quarterly and annually datasets related to public debt statistics are provided by the ECB, one denoted as "Government Statistics - GST" and second as "Government Finance Statistics - GFS". The GST is the older dataset based on ESA 95 framework while the GFS is the newer dataset based on ESA 2010. In addition to these two datasets, the ECB also provides annual data on public debt reported by the European Commission from the EDP tables, which is denoted as EDP dataset. The following table summarizes main features of these three datasets:

[37] As explained on the website of ECB, "The ECB collects the annual government finance statistics (GFS) on individual countries directly from the National Central Banks (NCBs) The ECB receives the quarterly non-financial accounts data from the individual countries via Eurostat. Quarterly financial accounts for general government and quarterly Maastricht debt are received directly from the national compilers (NSIs or NCBs)."

Available datasets on government debt in EU countries

Dataset	GST	GFS	EDP
Framework	ESA 95	ESA 2010	Excessive deficit procedure
Frequency	Annual, quarterly	Annual, quarterly	Annual
Source	NCBs for annual, Eurostat for quarterly	NCBs for annual, Eurostat for quarterly	European Commission
Public debt definition	Maastricht, in line with ESA 95 provisions on financial liabilities	Maastricht, in line with ESA 2010 provisions on financial liabilities	Maastricht, in line with ESA 2010 provisions on financial liabilities
Typical coverage of annual data	1995-2013, disconnected since 2014	1995-ongoing, the most recent available 2014	2011-ongoing, the most recent available 2014
Typical coverage of quarterly data	2000Q1–2014Q1, disconnected since 2014Q2	2000Q1– ongoing, the most recent available	
Unit	Nominal value at national currency, % of GDP	Nominal value at national currency, % of GDP	Nominal value at national currency, % of GDP

Source: *the ECB website, retrieved at October 2015.*

The main dataset used in this work denoted as DS1, is based on the quarterly data on primary balance, interest paid, gross government consolidated debt, and nominal and real growth retrieved from the ECB according to ESA 2010. The auxiliary dataset DS2 used in estimating the FRF is based on annual macroeconomic data from the World Economic Outlook Database of the IMF. The auxiliary dataset DS3 used in out-of-sample analysis and it mirrors DS1, but with ESA 95 data.

Dataset DS1 – annualized quarterly data, ECB

The dataset DS1 is derived following the DAE. The general form of the debt accumulation equation, as provided in Chapters 2 and 3, assumes the annual frequency of the data observations in the empirical analysis. As I work with quarterly observations of annualized data, proper form of the DAE (in terms of potential GDP) is:

$$d_t^p - d_{t-1}^p = \frac{r_t - \pi_t(1 + rg_t^p) - rg_t^p}{(1 + rg_t^p)(1 + \pi_t)} d_{t-1}^p - capb_t^p - as_t^p + dd_t^p,$$

where time index t refers to quarter instead of year, and the time series consists of quarterly observations of annualized data. In order to provide such time series, I made some transformations of the raw dataset to assure the correspondence of annualized flow variables with stock variables, which is explained in detail in the rest of this section.

Basically, I use three types of variables: pure flow variables, pure stock variables and combination of the flow and stock variables (shares in GDP). The frequency of all variables is quarterly. Superscript Q refers to quarterly (three-month) values of pure flow variables. Otherwise, variables are either annualized flow variables (rolling sum of current and previous three quarters), stock variables or combination of stock variables and annualized values of flow variables.

The first step in data transformation is getting the missing quarterly observations of time series that can be fully derived from the raw dataset, more precisely nominal current GDP, overall government balance, equation value of the public debt and debt-deficit adjustment. I compute quarterly time series of GDP in nominal terms of the national currency (at market prices) using absolute and relative corresponding values of the primary balance:

$$Y_t^Q = \frac{PB_t^Q}{pb_t^Q},$$

Further, by subtraction of the interest payment from the primary balance, I obtain quarterly values of the overall government balance

$$OB_t^Q = PB_t^Q - INT_t^Q,$$

calculate equation values of the government debt as given by the debt accumulation equation

$$D_t^* = D_{t-1} - OB_t^Q,$$

and then compute quarterly values of debt-deficit adjustment

$$DD_t^Q = D_t - D_t^*.$$

Eventually, as values of the potential GDP are needed, I use filters to obtain quarterly observations of the potential nominal GDP $Y_t^{p,Q}$.

Annualized values of all flow variables Z_t (primary balance PB_t, overall government balance OB_t, actual nominal GDP Y_t, potential nominal GDP Y_t^p, real GDP RY_t, government revenue R_t, government expenditure G_t, interest payment INT_t, and debt-deficit adjustment DD_t) are obtained as a rolling sum of the current and the three previous quarterly observations,

$$Z_t = \sum_{j=t-3}^{t} Z_j^Q .$$

Once the annualized quarterly observations of the time series in absolute terms are computed, I proceed to the next step of getting the relevant inputs for computation of interest – growth differential. These include the following annualized rates: implied interest rate, inflation rate and real GDP growth rate. Annualized implied interest rate is computed as

$$r_t = \frac{INT_t}{D_{t-4}}$$

to reflect annual rate of change in debt servicing cost. Further, I compute annualized GDP deflator P_t in standard manner:

$$P_t = \frac{Y_t}{RY_t} .$$

This allows us to compute inflation rate as the annual change of GDP deflator,

$$\pi_t = \frac{P_t}{P_{t-4}} - 1.$$

The annual real GDP growth rates of actual and potential GDP are computed as

$$rg_t = \frac{RY_t}{RY_{t-4}} - 1, \quad rg_t^p = \frac{RY_t^p}{RY_{t-4}^p} - 1$$

where values of the potential real GDP are previously obtained by deflating nominal values of potential GDP with corresponding GDP deflator, $RY_t^p = Y_t^p / P_t$.

In the last step I decompose primary balance to cyclically-adjusted and automatic stabilizers components, according to the methodology described in Chapter 2. After computing quarterly observations of the primary expenditures PG_t^Q by subtracting the interest rate from overall expenditures, $PG_t^Q = G_t^Q - INT_t^Q$, I calculate quarterly observations of cyclically-adjusted primary balance according to the equation:

$$CAPB_t^Q = R_t^Q \left(\frac{Y_t^{p,Q}}{Y_t^Q}\right) - PG_t^Q.$$

Then quarterly series of automatic stabilizers is computed as a difference of headline and cyclically-adjusted primary balance,

$$AS_t^Q = PB_t^Q - CAPB_t^Q.$$

Quarterly observations of the cyclically-adjusted primary balance and automatic stabilizers are annualized in the same fashion as the other flow variables.

Eventually, I switch from absolute values of the annualized flow variables Z_t to relative term z_t or z_t^p, by scaling them either with actual or potential nominal GDP, respectively, depending on required inputs of the debt accumulation equation:

$$z_t = \frac{Z_t}{Y_t}, \quad z_t^p = \frac{Z_t}{Y_t^p}.$$

Dataset DS2 – Annual data, IMF

Data definition and sources

Variable	Definition	Abbreviation	Source
Primary balance to GDP	Overall balance minus net interest expenditure scaled by either actual or potential GDP	PB_A if non-adjusted; CA_PB_A or CA_PB_P if adjusted	WEO, IMF except for Serbia, Macedonia, B&H and Moldova, where data are retrieved from IMF country reports
Government debt to GDP	Government debt according to ESA95 definition scaled by actual GDP	gd_GDP or L.gd_GDP if lagged	WEO, IMF
Output gap to GDP	Difference between actual and potential GDP scaled by potential GDP	OG	WEO, IMF for actual GDP, author's calculation for potential GDP
Crisis Dummy	Takes value 1 in year 2009 for all countries	cris	
Election Dummy	Takes value 1 in year of	elec	Web presentations of

	parliamentary elections for given country		EEC governments and parliaments
Foreign direct investments to GDP	Inward FDI flow in USD at current exchange rate scaled by GDP in USD	fdi_GDP	UNCTAD statistics for FDI, WEO IMF for GDP in USD
Terms of trade, change	First difference of terms of trade index	d_tot	WEO, IMF
Openness to GDP	Sum of export and import scaled by actual GDP	open	WEO, IMF
Private investments to GDP	Private gross capital formation scaled by actual GDP	pr_inv_GDP	WEO, IMF
Inflation	Percentage annual change of GDP deflator	infl	WEO, IMF

Data coverage per country and year

Country	**Primary balance**
Albania	1997
Bosnia & Herzegovina	2004
Croatia	2002
Macedonia	2000
Montenegro	2002
Serbia	2002
Bulgaria	2002
Czech Republic	1995
Hungary	1995
Poland	1995
Romania	2004
Slovakia	1997
Slovenia	1995
Estonia	2003
Latvia	2003
Lithuania	2000
Belarus	1998
Moldavia	2004
Russia	1998
Ukraine	2004
Turkey	1997

Appendix B: Matlab code for VAR-FRF analysis (on example of Bulgaria)

```
% Data import (XY=*_var)

XY=importdata('/Users/AZ1111/Dropbox/RM PD papers/Data/bgr_var.txt');

H=16 % forecast horizon
P=4 % out-of-sample cut-off

% computing VAR(2) coefficients, 4 variables (interest rate, growth, fx, infl)

X=XY(1:length(XY)-P,1:4)
T=length(X)
Xtran=transpose(X(3:T,1:4));
X0=ones(T-2,1);
X1=X(2:T-1,1:4);
X2=X(1:T-2,1:4);
Xbig=[X0 X1 X2];
G=Xtran*Xbig*inv(transpose(Xbig)*Xbig);
C=G(:,1)
A1=G(:,2:5)
A2=G(:,6:9)

% computing VCV

Xprim=transpose(X);

Xhat=zeros(4,T-2);
for t=3:T
Xhat_t(:,t)= C+A1*Xprim(1:4,t-1)+A2*Xprim(1:4,t-2);
Xhat(:,t-2)=Xhat_t(:,t);
end

Uhat=X(3:T,:)-transpose(Xhat);

SigmaU= transpose(Uhat)* Uhat/T;

% SVAR estimation

B_low=chol(SigmaU,'lower')
B_up=chol(SigmaU,'upper')


% point forecast

GGD=XY(:,5)

Xprim=transpose(X);
Th=T+1
```

```
for h=1:H
Xpred(:,h)=C+A1*Xprim(1:4,Th-1)+A2*Xprim(1:4,Th-2);
Xprim=[Xprim Xpred(:,h)];
Th=Th+1;
end

GGDprim=transpose(GGD)

Th=T+1
for h=1:H
dIRDpred(:,h)= (Xprim(1,Th)- Xprim(4,Th)*(1+Xprim(2,Th)))./((1+ Xprim(2,Th))*(1+
Xprim(4,Th)));
IRDpred(:,h)= GGDprim(1,Th-4)* dIRDpred(:,h);
dRGDpred(:,h)= -(Xprim(2,Th))./((1+ Xprim(2,Th))*(1+ Xprim(4,Th)));
RGDpred(:,h)=GGDprim(1,Th-4)* dRGDpred(:,h);
GGDprim=[GGDprim (IRDpred(:,h)+ RGDpred(:,h)+ GGDprim(1,Th-4))];
Th=Th+1;
end
```

% stochastic forecast of non-fiscal variables

```
clear n Xpred_s Xprim_s Xprim_sh

for sim=1:1000
        Xprim_s= transpose(X);
        for h=1:H
        n(:,h,sim)=B_up*normrnd(0,1,[4,1]);
        Xpred_s(:,h,sim)= Xpred(:,h)+ n(:,h,sim);
        Xprim_s =[Xprim_s Xpred_s(:,h,sim)];
        end
        Xprim_sh(:,:,sim) = Xprim_s;
end

clear IRDpred_s RGDpred_s GGDprim_s GGDprim_sh

for sim=1:1000

        GGDprim_s=transpose(GGD);

        Th=T+1;
        for h=1:H;
        dIRDpred_s(:,h,sim)= (Xprim_sh(1,Th,sim)-
        Xprim_sh(4,Th,sim)*(1+Xprim_sh(2,Th,sim)))./((1+Xprim_sh(2,Th,sim))*(1+
        Xprim_sh(4,Th,sim)));
        IRDpred_s(:,h,sim)= GGDprim_s(1,Th-4)* dIRDpred_s(:,h,sim);
        dRGDpred_s(:,h,sim)= -(Xprim_sh(2,Th,sim))./((1+ Xprim_sh(2,Th,sim))*(1+
        Xprim_sh(4,Th,sim)));
        RGDpred_s(:,h,sim)= GGDprim_s(1,Th-4)* dRGDpred_s(:,h,sim);
```

```
        GGDprim_s=[GGDprim_s (IRDpred_s(:,h,sim)+ RGDpred_s(:,h,sim)+
        GGDprim_s(1,Th-4))];
        Th=Th+1;
        end
GGDprim_sh(:,:,sim)= GGDprim_s;
end
```

% output gap

```
GDP=XY(:,7:8)
GDPfcs=[ 0.015      0.015   0.015   0.015   0.025   0.025   0.025   0.025   0.035   0.035
        0.035   0.035    0.045  0.045   0.045   0.045] % 2012 forecast

clear GDPprim OGgap GDPpred OGgap_pred

GDPprim=transpose(GDP);
OGgap=(GDPprim(1,:)-GDPprim(2,:))./GDPprim(2,:)

Th=T+1
for h=1:H
GDPpred(1,h)= GDPprim(1,Th-4)*(1+GDPfcs(:,h));
GDPpred(2,h)= GDPprim(2,Th-4)*(1+ Xpred(2,h));
OGgap_pred(:,h)=(GDPprim(1,h)-GDPprim(2,h))./GDPprim(2,h);
GDPprim=[ GDPprim GDPpred(:,h)];
OGgap=[OGgap OGgap_pred(:,h)];
Th=Th+1;
end
```

% deterministic forecasts of debt and primary balance

```
PB=XY(:,6)
PBprim=transpose(PB);
GGDprim0=GGDprim
```

% point forecast, primary balance historic average scenario

```
clear GGDpred0 PBpred0 GGDprim0

GGDprim0=GGDprim
PB_M=mean(PB)
PBpred0=repmat(PB_M,1,H)

Th=T+1
for h=1:H
GGDpred0(:,h)= GGDprim0(:,Th)-PBpred0(:,h);
Th=Th+1
end
GGDprim0(:,T+1:T+H)= GGDpred0;
```

% FRF BASELINE

% point forecast: historic Gamma average + no policy change

```
OG_coeff=[-0.20715]
GGD_coeff=[ 0.026454]
Gamma=[ -0.011898256]
Lambda=[0.00]

% Lambda=[1] % fiscal consolidation
% Lambda=[-1] % fiscal stimulus

clear GGDpred1 PBpred1 GGDprim1

GGDprim1=GGDprim(:,1:T)

Th=T+1;
for h=1:H
PBpred1(:,h)=(Gamma+ Lambda)+GGD_coeff*GGDprim1(:,Th-1)+ OG_coeff*
OGgap(:,Th);
IRDpred1(:,h)= GGDprim1(1,Th-4)* dIRDpred(:,h);
RGDpred1(:,h)=GGDprim1(1,Th-4)* dRGDpred(:,h);
GGDpred1(:,h)= GGDprim1(1,Th-4)+IRDpred1(:,h)+ RGDpred1(:,h)- PBpred1(:,h);
GGDprim1=[GGDprim1 GGDpred1(:,h)];
Th=Th+1;
end

GGDpred1_sm=smooth(GGDprim1(:,T+1:T+H));
GGDprim1_sm=[GGDprim1(:,1:T) transpose(GGDpred1_sm)];
```

% stochastic forecasts: historic Gamma average + fiscal policy expectations

```
PBres_sd=[ 0.014753578]

clear GGDpred1_s PBpred1_s GGDprim1_s GGDprim1_sh

for sim=1:1000
    GGDprim1_s=GGDprim(:,1:T);
    Th=T+1;
    for h=1:H
    PBpred1_s(:,h,sim)= PBpred1(:,h)+ PBres_sd* normrnd(0,1);
    IRDpred1_s(:,h,sim)= GGDprim1_s(1,Th-4)* dIRDpred_s(:,h,sim);
    RGDpred1_s(:,h,sim)=GGDprim1_s(1,Th-4)* dRGDpred_s(:,h,sim);
    GGDpred1_s(:,h,sim)= GGDprim1_s(1,Th-4)+IRDpred1_s(:,h,sim)+
    RGDpred1_s(:,h,sim)- PBpred1_s(:,h,sim);

    GGDprim1_s=[GGDprim1_s GGDpred1_s(:,h,sim)];
```

```
        Th=Th+1;
        end
GGDprim1_sh(:,:,sim)=GGDprim1_s;
end
```

% fanchart

```
clear GGDprim1_sh_fch GGDpred1_sh_fch

for sim=1:1000
GGDprim1_sh_fch(sim,:)=GGDprim1_sh(:,:,sim);
GGDprim1_sh_sm(:,sim)= smooth(GGDprim1_sh_fch(sim,T+1:T+H));
GGDprim1_sh_fch(sim,T+1:T+H)=transpose(GGDprim1_sh_sm(:,sim));
end

GGDpred1_sh_fch= GGDprim1_sh_fch(:,T+1:T+H);

f1=figure;
figure (f1)
fanChart(1:size(transpose(GGDprim1_sh_fch),1),transpose(GGDprim1_sh_fch));
```

% FRF debt stabilizing policy, no fiscal consolidation

% point forecast: historic Gamma average + fiscal policy expectations

```
OG_coeff=[-0.20715]
GGD_coeff=[0]
Gamma=[ -0.011898256]
Lambda=[0.00]
```

% Lambda=[1] % fiscal consolidation
% Lambda=[-1] % fiscal stimulus

% Lambda=[1] % fiscal consolidation
% Lambda=[-1] % fiscal stimulus

```
clear GGDpred2 PBpred2 GGDprim2

GGDprim2=GGDprim(:,1:T)

Th=T+1;
for h=1:H
PBpred2(:,h)=(Gamma+ Lambda)+GGD_coeff*GGDprim2(:,Th-1)+ OG_coeff*
OGgap(:,Th);
IRDpred2(:,h)= GGDprim2(1,Th-4)* dIRDpred(:,h);
RGDpred2(:,h)=GGDprim2(1,Th-4)* dRGDpred(:,h);
GGDpred2(:,h)= GGDprim2(1,Th-4)+IRDpred2(:,h)+ RGDpred2(:,h)- PBpred2(:,h);
GGDprim2=[GGDprim2 GGDpred2(:,h)];
```

```
Th=Th+1;
end

GGDpred2_sm=smooth(GGDprim2(:,T+1:T+H));
GGDprim2_sm=[GGDprim2(:,1:T) transpose(GGDpred2_sm)];
```

% stochastic forecasts: historic Gamma average + fiscal policy expectations

```
PBres_sd=[ 0.014753578]

clear GGDpred2_s PBpred2_s GGDprim2_s GGDprim2_sh

for sim=1:1000
        GGDprim2_s=GGDprim(:,1:T);
        Th=T+1;
        for h=1:H
        PBpred2_s(:,h,sim)= PBpred2(:,h)+ PBres_sd* normrnd(0,1);
        IRDpred2_s(:,h,sim)= GGDprim2_s(1,Th-4)* dIRDpred_s(:,h,sim);
        RGDpred2_s(:,h,sim)=GGDprim2_s(1,Th-4)* dRGDpred_s(:,h,sim);
        GGDpred2_s(:,h,sim)= GGDprim2_s(1,Th-4)+IRDpred2_s(:,h,sim)+
        RGDpred2_s(:,h,sim)- PBpred2_s(:,h,sim);

        GGDprim2_s=[GGDprim2_s GGDpred2_s(:,h,sim)];
        Th=Th+1;
        end
GGDprim2_sh(:,:,sim)=GGDprim2_s;
end
```

% fanchart

```
clear GGDprim2_sh_fch GGDpred2_sh_fch

for sim=1:1000
GGDprim2_sh_fch(sim,:)=GGDprim2_sh(:,:,sim);
GGDprim2_sh_sm(:,sim)= smooth(GGDprim2_sh_fch(sim,T+1:T+H));
GGDprim2_sh_fch(sim,T+1:T+H)=transpose(GGDprim2_sh_sm(:,sim));
end


GGDpred2_sh_fch= GGDprim2_sh_fch(:,T+1:T+H);

f2=figure;
figure (f2)
fanChart(1:size(transpose(GGDprim2_sh_fch),1),transpose(GGDprim2_sh_fch));
```

% FRF debt stabilizing policy, fiscal consolidation

% point forecast: historic Gamma average + fiscal policy expectations

```
OG_coeff=[0]
GGD_coeff=[ 0.026454]
Gamma=[ -0.011898256]
Lambda=[0.00]


% Lambda=[1] % fiscal consolidation
% Lambda=[-1] % fiscal stimulus

clear GGDpred3 PBpred3 GGDprim3

GGDprim3=GGDprim(:,1:T)

Th=T+1;
for h=1:H
PBpred3(:,h)=(Gamma+ Lambda)+GGD_coeff*GGDprim3(:,Th-1)+ OG_coeff*
OGgap(:,Th);
IRDpred3(:,h)= GGDprim3(1,Th-4)* dIRDpred(:,h);
RGDpred3(:,h)=GGDprim3(1,Th-4)* dRGDpred(:,h);
GGDpred3(:,h)= GGDprim3(1,Th-4)+IRDpred3(:,h)+ RGDpred3(:,h)- PBpred3(:,h);
GGDprim3=[GGDprim3 GGDpred3(:,h)];
Th=Th+1;
end

GGDpred3_sm=smooth(GGDprim3(:,T+1:T+H));
GGDprim3_sm=[GGDprim3(:,1:T) transpose(GGDpred1_sm)];
```

% stochastic forecasts: historic Gamma average + fiscal policy expectations

```
PBres_sd=[ 0.014753578]

clear GGDpred3_s PBpred3_s GGDprim3_s GGDprim3_sh

for sim=1:1000
        GGDprim3_s=GGDprim(:,1:T);
        Th=T+1;
        for h=1:H
        PBpred3_s(:,h,sim)= PBpred3(:,h)+ PBres_sd* normrnd(0,1);
        IRDpred3_s(:,h,sim)= GGDprim3_s(1,Th-4)* dIRDpred_s(:,h,sim);
        RGDpred3_s(:,h,sim)=GGDprim3_s(1,Th-4)* dRGDpred_s(:,h,sim);
        GGDpred3_s(:,h,sim)= GGDprim3_s(1,Th-4)+IRDpred3_s(:,h,sim)+
        RGDpred3_s(:,h,sim)- PBpred3_s(:,h,sim);

        GGDprim3_s=[GGDprim3_s GGDpred3_s(:,h,sim)];
        Th=Th+1;
        end
GGDprim3_sh(:,:,sim)=GGDprim3_s;
```

```
end
```

% fanchart

```
clear GGDprim3_sh_fch GGDpred3_sh_fch

for sim=1:1000
GGDprim3_sh_fch(sim,:)=GGDprim3_sh(:,:,sim);
GGDprim3_sh_sm(:,sim)= smooth(GGDprim3_sh_fch(sim,T+1:T+H));
GGDprim3_sh_fch(sim,T+1:T+H)=transpose(GGDprim3_sh_sm(:,sim));
end

GGDpred3_sh_fch= GGDprim3_sh_fch(:,T+1:T+H);

f3=figure;
figure (f3)
fanChart(1:size(transpose(GGDprim3_sh_fch),1),transpose(GGDprim3_sh_fch));
```

% point forecast summary

```
clear GGDpred_all GGDpred_all_sm

GGDpred_all_sm=transpose([GGDpred1_sm GGDpred2_sm GGDpred3_sm]*100);
% GGDpred_all=transpose([transpose(GGDpred1) transpose(GGDpred2);
transpose(GGDpred3)]);
```

% probability defaults

```
clear GGDtrash GGDdprob GGDdprob_m

GGDtrash=ones(sim,H)*mean(GGD);
GGDdprob=transpose((GGDpred1_sh_fch-GGDtrash) ./GGDpred1_sh_fch);
for h=1:H
for sim=1:1000
if GGDdprob(h,sim)<0
GGDdprob(h,sim)=0;
end;
end;
end;
GGDdprob_m=sum(transpose(GGDdprob/T));
```