KU LEUVEN

CENTER FOR ECONOMIC STUDIES

DISCUSSION PAPER SERIES
DPS15.12

JUNE 2015

Fiscal rule infringement risks: a stochastic characterization of EMU budgets and their discipline

Wouter VAN DER WIELEN

Energy, Transport and Environment

Faculty of Economics
And Business

Fiscal Rule Infringement Risks: A Stochastic Characterization of EMU Budgets and Their Discipline[*]

Wouter van der Wielen[†]

June 19, 2015

Abstract

With the recent debt crisis, the necessity of effective measures for safeguarding fiscal sustainability has become patent, leading to an intense debate. Most of the debate focuses on strengthening fiscal rules and restoring fiscal imbalances through austerity measures. In this paper, I address two issues impeding the success of these measures: macroeconomic uncertainty and fiscal policy reaction. Specifically, I apply a structural VAR model to characterize the shocks to growth, inflation and interest rates. In combination with the estimation of fiscal reaction functions, this allows for the application of a Monte Carlo-based approach for deriving the distribution of uncertainty of fiscal realizations. Furthermore, the model quantifies fiscal rule infringement risks and the distribution of the adjustment necessary to restore sustainability. The model thus lends empirical support to recent literature emphasizing uncertainty as essential to the appraisal of a country's fiscal position. Results suggest that the Italian debt path is typified by higher intrinsic uncertainty than its European counterparts. Yet, taking into account the behavioral uncertainty of fiscal policy makers, Spain is the most likely country not to live up to the debt brake in the medium-run. This may impel the enforcement of stricter surveillance to hedge against disadvantageous outcomes.

Keywords: Fiscal Discipline, MTOs, Stochastic Projections, Stabilization, Fiscal Reaction Function

JEL codes: C53, E32, E37, H62, H68

---

[*] I would like to thank Stef Proost and André Decoster for their support and counsel during my graduate studies. This paper greatly benefited from detailed discussion with Ruben Schoonackers and Geert Langenus. Furthermore, I gratefully acknowledge helpful comments by Raf Wouters, Hans Dewachter and the seminar participants at the NBB. This paper emanated from a three-month visit to the National Bank of Belgium's research department on the occasion of its Trainee Programme for Young Researchers. Accordingly, I would like to express my sincere gratitude for the opportunity to benefit from the productive environment provided by its staff. The views expressed in this paper are those of the author and do not necessarily represent those of the National Bank of Belgium. The latter can also not be held accountable for the uses of this text.

[†] KU Leuven, Center for Economic Studies, Naamsestraat 69, 3000 Leuven, Belgium. Email: *wouter.vanderwielen@kuleuven.be*. Telephone: +32/16326655

1 Introduction

In recent decades, oil crises and ensuing recessions, political instability, and structural problems have contributed to the deterioration of public finances worldwide. Furthermore, both the gradual deregulation of the financial sector starting in the 1980s and the US housing bubble resulted in a worldwide financial crisis from 2007 onwards. The subsequent bailouts of financial institutions caused the public debt in the EMU to rise steeply. In addition, the public debt of some member state countries was already at a high level in comparison to other developed countries. This led the financial markets to argue that the public finances of some EMU member states had become unsustainable, leading to a European debt crisis.

It is agreed upon by academics and practitioners that there is a necessity for effective fiscal measures to safeguard the sustainability of public finances, but that they should not hamper economic recovery. Although fiscal sustainability has a well-developed economic logic, there has been less consensus on how to determine the stringency of the instruments called upon. The analysis of budgetary targets is especially hindered by the uncertainty that is inherint in macroeconomic forecasts. Given the importance of budgetary uncertainty, stochastic analysis of fiscal balances and the resulting debt stocks is now common practice. The EC and IMF typically provide confidence intervals for the budgetary projections in their Debt Sustainability Analyses (DSAs). Similarly, fan-charts and scenario analyses of future debt paths are provided. The IMF's World Economic Outlook and the EC's Sustainability Reports are prime examples.

More recently, policy advice is pushed towards constructing a probability function of public debt using Monte Carlo simulations taking into account the uncertainty in economic growth rates, interest rates and the policy makers' discretionary reaction to increasing debt levels (see e.g. Celasun et al., 2007; Budina and van Wijnbergen, 2008). Constructing a probabilistic model of the future path of the fiscal balance and the resulting debt-to-GDP ratio provides useful insights on the required stringency of fiscal targets. Nonetheless, the respective literature has mainly focused on the reaction coefficient of the primary balance with regards to the debt-to-GDP ratio and has ignored the direct implications for fiscal disciplinary measures.

A first objective of this paper is therefore to build on this methodology and arrive at enhanced stochastic projections of EMU member states' public finances. This is done by improving upon the discretionary fiscal policy component in these models. For example, by considering the impact of underlying institutional and macro-financial factors remedies the restricted specification of discretionary fiscal policy changes that have been used up till now. Secondly, the model presented in this paper allows for the application of Value-at-Risk measures and, more importantly, provides useful insights with respect to the stringency of fiscal discipline. After all, little research has focused on the complexity of achieving fiscal discipline under uncertainty. Thus, by incorporating the way that different sources of uncertainty may influence the outlook of fiscal discipline, a fruitful research environment is created. Thirdly, constructing a measure to evaluate whether medium-term budgetary targets - such as EMU member states' Stability Programmes - are attainable will be a major contribution of this paper. Hence, this paper provides ground for recommendations on whether medium-term budgetary targets are too strict or actually insufficiently stringent.

The model is constructed as follows. First, the unexpected shocks to the macro variables in the debt dynamics equation are characterized using the joint dynamics of their forecast errors, which are derived from a vector autoregression (VAR) model. Specifically, this paper applies a Monte Carlo-based probabilistic approach to derive the distribution of shocks to growth, inflation and interest rates from their past shocks. Second, I analyze the stabilization of fiscal policy via automatic stabilizers as well as its discretionary reaction to, among other things, public debt and institutional rules. I illustrate the methodology by studying the case of 28 European countries. Finally, putting both parts together by iterating the law of motion of debt forward leads to stochastic debt simulations. In particular, the model computes first the distribution of fiscal adjustment necessary to restore sustainability and, second, risk measures that quantify the likelihood of fiscal rule infringements of (i) member states' Stability Programmes, (ii) the debt brake rule and (iii) the adjustment path of the cyclically adjusted budget balance towards the medium-term objective.

The remainder of this paper is structured as follows. The next section gives a more comprehensive overview of the research on which this paper builds. Section 3 outlines the methodology and estimation of the building blocks underlying the probabilistic model. Furthermore, it presents the resulting expected paths of the EMU's future public finances. Next, section 4 proceeds to the analysis of their implications for fiscal discipline. Section 5 presents robustness checks. Finally, section 6 provides some concluding remarks.

2 Literature

2.1 Fiscal Discipline

A frequently proposed way of achieving fiscal discipline and preventing profligacy is to implement budgetary constraints, also called fiscal rules. In Europe fiscal rules regained attention during the 1990s due to their anti-inflationary role in the Treaty of Maastricht. The Treaty imposed, among other entrance requirements, the necessity for candidate member states of the EMU to preclude excessive budget deficits. Once the monetary union came into existence, the Stability and Growth Pact retained the same constraint for the headline deficit and, additionally, required participants to follow a medium-term budgetary stance close to balance or in surplus.

In 2005 a revision in favor of a more contextual approach (further) opened the door to a loosened implementation. Whereas the headline deficit could still not exceed 3% of GDP, countries with a debt rate below the benchmark (i.e. lower than 60% of GDP) could run a structural deficit of 1% of GDP in the medium run (i.e. a Medium-Term Objective, MTO).[1] Highly indebted countries, on the other hand, had to achieve a structural balance or small surplus in the medium run. Since then all Member States have had to reach their MTOs or be on an appropriate adjustment path towards it, with an annual improvement in their structural balance of 0.5% of GDP. In the case that economic growth exceeds expectations, this adjustment should be higher to allow for more flexibility during economic downturns. The crisis-driven implementation of the Six-Pack, European Semester and Fiscal Compact nonetheless revamped the focus on national budget balances.

Although the European Semester created an institutional formalization of the schedule for EMU member states' annual growth surveys, draft budgetary plans, Stability Programmes and the EC's country-specific recommendations to improve the coordination between macroeconomic circumstances, structural issues and budgeting, the Six-Pack and Fiscal Compact tightened national budgeting again. In particular under the Six-Pack, countries on their adjustment path towards the MTO must also contain their expenditure growth at a rate lower than medium-term potential GDP growth, unless matched by discretionary revenue measures. For member states at their MTO, any excess growth of new expenditures over the reference rate of potential GDP growth must be matched by discretionary revenue measures.[2] Moreover, member states agreed to move towards

---

[1] The structural balance is defined as the cyclically adjusted budget balance (CABB) net of one-off and temporary measures. In practice, the EC already used the CABB for the evaluation of member states' fiscal policies from 2003 onwards.

[2] The MTO, however, has been redefined to entail a country-specific reference value for individual Member States' medium-term budgetary positions, defined in structural terms ensuring member states: (a) are on course to a sustainable debt position, taking into account the economic and budgetary impact of ageing populations; and (b) have adequate room for budgetary maneuver, in particular taking into account the needs for public investment. The MTOs are updated every three years or more frequently if a member state has undergone a structural reform

the MTO with more than 0.5% of GDP in the case of high indebtedness. Euro area countries that are signatories to the Treaty on Stability, Coordination and Governance (i.e. the Fiscal Compact) additionally committed themselves to MTOs with a structural deficit of 0.5% of GDP or better, unless the debt rate is significantly low and there are low risks for fiscal sustainability. The analysis of the MTO or the adjustment path towards it under the preventive arm of the SGP is thus judged by an assessment of the structural budget balance, complemented by an analysis of the growth rate of net expenditures.

Next to the renewed (structural) budget balance requirements within the Six-Pack to prevent an Excessive Deficit Procedure (EDP), the member states adherence to the debt criterion was made more binding via a debt brake rule. To prevent ending up in the EDP, countries with a debt rate exceeding 60% of GDP have to reduce the difference by a minimum of 5 pp. per year over a period of three years.[3]

Ultimately, despite its strong embeddedness in European policy, the debate on whether borrowing constraints are a panacea still remains, as the jury is still out on whether they are too strict or, on the contrary, not stringent enough. A vast number of studies have pointed to the positive impact fiscal rules may have on fiscal balances (see e.g. EC, 2009; Debrun et al., 2008; Hallerberg et al., 2007; Krogstrup and Wälti, 2008). Moreover, the restrictive impact on public finances via the preventative excessive deficit procedure ought to reduce susceptibility to unsustainability, aided by the consequently enhanced predictability and the higher credibility of fiscal policy. Nonetheless, serious criticism of the conception of EMU rules has been voiced (see e.g. Buiter et al., 1993) and econometric identification problems remain a major concern. Additionally, the adverse impact of fiscal rules on public investment is documented by, for example, Servén (2007) and Bacchiocchi et al. (2011). Consequently, inferring the strictness and likeliness of the targets set out in (i) member states' Stability Programmes, (ii) the debt brake rule and (iii) the adjustment path towards the MTO offers perspective to the debate.

2.2 Uncertainty

Uncertainty is ubiquitous and thus surrounds fiscal policy. The sustainability concept driving disciplinary actions, for instance, is forward-looking, but uncertainty makes it difficult to assess in practice. To compensate, stochastic analysis of fiscal balances and the resulting debt stocks is now standard practice (see e.g. Chalk and Hemming, 2000; IMF, 2003; EC, 2012; IMF, 2012), including: (a) sensitivity analyses (or stress tests), shocking variables driving public debt by two standard deviations, i.e. providing a worst case scenario; and (b) scenario analyses, with less extreme assumptions about the driving processes.

The traditional stochastic analyses, however, have several major shortcomings (Celasun et al., 2007). By shocking the underlying variables separately the joint dynamics of the underlying macroeconomic variables are not necessarily respected. Moreover, each ad hoc debt trajectory on its own has a zero probability of occurring in practice.

Recently, these shortcomings have been tackled by constructing a probability function of public debt using Monte Carlo simulations taking into account the uncertainty in economic growth rates, interest rates and policy makers' discretionary reaction to increasing debt levels (see e.g. Celasun et al., 2007; Budina and van Wijnbergen, 2008). Nonetheless, the respective literature has mainly

---

significantly impacting its public finances.

[3] Countries in the EDP are exempt from this requirement to prevent additional problems. Upon leaving the EDP they enter into a three-year transition period requiring a minimum linear structural adjustment of the structural balance to assure they end up on an acceptable adjustment path once this transition period is over. For example, Belgium was required to adjust its balance by 0.33 pp. in 2014 to reach the MTO by 2016 and ensure that the high debt ratio is put on a firm path downward.

focused on the reaction coefficient of the primary balance with regards to the debt-to-GDP ratio and has ignored the direct implications for fiscal disciplinary measures.

The fiscal rule literature, in its turn, mainly encompasses frameworks considering cyclical shocks, showing how balanced budget rules forgo stabilization benefits, how simple deficit-output limits in general encourage procyclical policy (when the economy is in intermediate states) and how cyclical adjustments of the target balance are therefore necessary to allow for stabilization in the case of adverse cyclical shocks. Next to ensuring fiscal sustainability, they ideally prevent a procyclical bias in fiscal policy by forcing policy makers to build up reserves during booms (Perotti, 2007).

Output gap projections, moreover, have been found to be significantly biased upward in several EMU member states (Jonung and Larch, 2006; Kempkes, 2012) as a result of their importance for cyclical corrections. The resulting bias of fiscal and economic forecasts in the EMU member states is found to depend strongly on the institutional setup, e.g. the design of the national budget process (von Hagen, 2010). Fiscal rules, for instance, have been found to increase the probability of accurate budget deficit projections and thus reduce policy uncertainty (Luechinger and Schaltegger, 2013). Nevertheless, the stochastic characteristics of the distribution of required fiscal adjustments has hardly been taken into account.

This paper thus contributes to two strands of literature. Firstly, this paper is distinct from the classical body of fiscal rule literature in its incorporation of macroeconomic uncertainty beyond cyclical fluctuations as well as the practical application thereof. Secondly, its results are distinct from traditional stochastic analyses in its analysis of fiscal rule infringement risks. Moreover, the model extends the estimation of the discretionary fiscal policy component in these models.

3 Methodological Framework

This section provides a comprehensive breakdown of the methodological framework. I start by deriving the law of motion of debt-to-GDP (section 3.1). This difference equation is solved iteratively forward in time which allows me to establish a projection of future sovereign debt. However, instead of considering one sole debt path, I simulate this equation numerous times under various macroeconomic conditions. This allows for the stochastic characterization of the EMU member states' public finances.

In order to come to stochastic projections, the estimation of fiscal and non-fiscal determinants must be separated due to, inter alia, the demand for more frequent than annual data by the time-series techniques used for estimating the variance-covariance matrix of shocks in non-fiscal determinants. In particular, country-specific vector autoregression (VAR) models are used to obtain simulations of the non-fiscal variables, respecting the joint dynamics of macroeconomic variables captured in past statistical trends (section 3.2). Next, an extended fiscal reaction function is estimated to obtain the responses of fiscal policy to the simulated economic conditions (section 3.3). A major part of such behavior is captured by conditioning on institutional and macro-financial controls as well as distinguishing between automatic stabilizers and discretionary policy.

In the end the quarterly VAR projections will be annualized and the corresponding debt paths can be computed using the debt evolution equation, which relates the debt ratio in a certain year with the debt ratio in the previous year, the primary balance (i.e. cyclical and discretionary fiscal policy) and other non-fiscal determinants.

3.1 Fundamental Debt Dynamics

Historically, the prevailing fiscal balance and accompanying level of public debt have been the main indicators recorded for the analysis of fiscal policy. In general, the law of motion of a government's debt can be written as follows

$$D_t = (1+r_t)D_{t-1} + PG_t - T_t = (1+r_t)D_{t-1} - PB_t \tag{1}$$

where D_t refers to the end-of-period public debt stock, r_t is the nominal interest rate, PG_t indicates the public expenditures excluding interest payments, T_t indicates the public revenues and PB_t stands for the primary balance at time t.[4]

Since output evolves over time, influencing the government's capacity to repay its debt, it is appropriate to express the former in terms of GDP ratios. Consequently, dividing equation (1) by real output yields

$$d_t = \frac{(1+r_t)d_{t-1}}{(1+g_t)(1+\pi_t)} - pb_t \tag{2}$$

where g_t denotes the real GDP growth rate at time t and π_t equals inflation, respectively.[5] Difference equation (2) relates the debt ratio d_t in a certain year t to the debt ratio in the previous year $t-1$, the primary balance as a percentage of GDP pb_t (i.e. cyclical and discretionary fiscal policy) and other non-fiscal determinants.

3.2 Non-fiscal Determinants

In keeping with the literature (see e.g. Garcia and Rigobon, 2004; Celasun et al., 2007; Budina and van Wijnbergen, 2008; Tanner and Samake, 2008; Cherif and Hasanov, 2012; Tielens et al., 2014), the baseline projections of the macroeconomic determinants, $\{g_t, \pi_t, r_t\}_{t=0}^{T}$, are constructed using a reduced form vector auto-regression model.[6] The VAR model also gives the estimated variance-covariance matrix of the shocks in the debt dynamics' non-fiscal determinants, Ω. Given their role as key parameters in the standard debt evolution equation, the shocks to economic growth rates, inflation rates and interest rates will be considered for generating alternative paths using Monte Carlo simulation. Specifically, the reduced form country-specific model can be summarized as follows:[7]

$$\begin{aligned} X_t &= F_1 X_{t-1} + ... + F_\tau X_{t-\tau} + u_t \\ \text{with} \quad X_t' &= [g_t, \pi_t, r_t] \\ \mathbb{E}[u_t u_t'] &= \Omega \\ u_t &\sim \mathcal{N}(0, \Omega) \end{aligned} \tag{3}$$

Dickey-Fuller tests are used to test for stationarity and the Akaike information criterion (AIC) is used to select the lag lengths τ.

---

[4] Note that exceptional bailouts of, for instance, financial institutions are not included. Logically, such expenses should be included in ΔD_t when they occur. Moreover, a more detailed law of motion would reflect that a government endogenously decides on the maturity and currency structure of its debt. An unconstrained country is likely to time the issue of public debt based on, for example, the interest rate. Overall, the omission of deficit-debt adjustments is not precarious (ECB, 2007).

[5] Solving this dynamic equation recursively and inserting the no-Ponzi scheme transversality condition results in the intertemporal budget constraint (IBC). For the econometric tests of the IBC a stationary real interest rate with mean r and a constant growth of GDP is typically assumed.

[6] An estimated dynamic stochastic general equilibrium (DSGE) model could act as a valid alternative (see e.g. in 't Veld et al., 2012). Nonetheless, the theoretical soundness as a result of specific assumptions on variable interactions in such structural macroeconomic models is traded off here against data coherence, in favor of the VAR framework.

[7] Other variables and shocks that are not part of the debt evolution equation still can have an impact on the debt accumulation and their impact can be recovered by including them in the VAR model.

There is a wide range of techniques available to estimate a VAR model representative for EMU member states. One could, for instance, estimate a panel VAR across all EMU member states. However, there is little reason to believe that the parameters are stable across member states and, given the small sample sizes in most member states, a random coefficient model would quickly exhaust the available degrees of freedom. Hence, I illustrate the model by applying the algorithm separately to data from five member states (Germany, France, Italy, Spain and Belgium), estimating a VAR on quarterly data from 1980Q1 to 2014Q2. Descriptives and data sources are summarized in table 13 in the appendix.

As mentioned above, augmented Dickey-Fuller tests are used to test for stationarity.[8] As expected, both GDP and inflation are non-stationary in levels. Interest rates are found to be $I(0)$ in most cases. The GDP series is therefore transformed into log differences and deseasonalized, running it stationary. Similarly, the inflation and interest series are differenced if necessary to obtain stationarity. Consequently, the null hypothesis of a unit root can be rejected at the 5% level or below for all variables. The results for the Akaike information criterion (AIC), the Bayesian information criterion (BIC) as well as the results for the likelihood ratio test are documented in table 15 in the appendix.

Typically, a recursive version of the VAR model is estimated in order to infer the structural shocks (ϵ_t):

$$\begin{aligned} AX_t &= B_1 X_{t-1} + ... + B_\tau X_{t-\tau} + \epsilon_t \\ \text{with} \quad F_l &= A^{-1} B_l \quad \text{for a given} \quad l = 1, ..., \tau \\ u_t &= A^{-1} \epsilon_t \end{aligned} \tag{4}$$

In keeping with the literature, the stochastic simulations that follow employ a Choleski factorization of the variance-covariance matrix of the residuals (see e.g. Garcia and Rigobon, 2004). Specifically, given the contemporaneous correlation of the errors, the estimated variance-covariance matrix is decomposed as follows: $\hat{\Omega} = A^{-1} A^{-1\prime}$, where A^{-1} is a 3×3 lower triangular matrix with the standard deviations of the structural shocks on its main diagonal. Then, quarterly shocks for the Monte Carlo simulations ($\tilde{\epsilon}$) are obtained by multiplying A^{-1} by a 3×1 vector of random draws from a standard normal distribution:[9]

$$\begin{aligned} \tilde{\epsilon} &= A^{-1} \zeta_t \\ \text{where} \quad \zeta_t &\sim \mathcal{N}(0,1) \end{aligned} \tag{5}$$

Repeating this simulation algorithm N times for a time horizon of T years (i.e. $T \times 4$ quarters) results in $4NT$ vectors of $\tilde{\epsilon}$. In the application that follows, 2.000 simulations are performed over a period of 5 years.[10]

---

[8] Nonetheless, the Phillips-Perron test, which is robust for unspecified autocorrelation and heteroskedasticity in the errors, results in the same conclusions.

[9] The factorization method is not sensitive to the ordering of variables in the VAR. Any Choleski decomposition will produce the same reduced form variance-covariance matrix. The ordering nonetheless matters for estimating the contemporaneous causality between macroeconomic variables. The ordering thus is only of interest for constructing impulse responses. Since the focus here is on obtaining the best predictor of the joint dynamics of the macro variables, I refrain from doing the latter. Section 5 moreover provides empirical endorsement for using the factorization in the form of robustness checks.

[10] This approach differs from the stochastic debt projection methods by di Giovanni and Gardner (2008) and Berti (2013), employed by the E.C. in its Sustainability Reports. Their approach differs from the aforementioned method in that the shocks to the non-fiscal determinants of debt dynamics are extracted from the variance-covariance matrix of historical shocks (assuming a joint normal distribution of the shocks), rather than from the estimated variance-covariance matrix in the context of a VAR model. The resulting shocks are then used to define the impact of uncertainty in macroeconomic conditions on public debt projections around a specific forecasted path.

As a matter of illustration figure 1 shows the uncertainty underlying the non-fiscal determinants, which will be used further on in the analysis, in the form of boxplots for each variable over the horizon T. The boxplots are based on 2.000 period-by-period Monte Carlo simulations of the estimated model using its estimated covariance matrix, $\hat{\Omega}$, as specified in equation (5). The algorithm thus straightforwardly allows for the construction of, for instance, the distribution for GDP and its growth rate throughout time.

The model's forecasting performance is to be evaluated. For succinctness, I restrict the discussion to the German case. Table 1 focuses on pseudo out-of-sample forecasts over the period from 2010Q1 to 2014Q2. As a comparison, it portrays the root mean squared errors of a univariate model and a vector autoregression model (each with four lags) and a random walk model. Table 1 indicates that the VAR consistently improves upon the univariate and the random walk forecast for both the full pseudo out-of-sample forecasts as a whole as well as for the rolling window forecasts. Accordingly, the VAR approach seems suitable to tackle the problem.

Table 1: Root Mean Squared Errors of Simulated Pseudo Out-of-sample Forecasts

	GDP growth			*Inflation*			*Interest Rate*		
	RW	*AR*	*VAR*	*RW*	*AR*	*VAR*	*RW*	*AR*	*VAR*
Full window	0.0172	0.0108	0.0080	0.0185	0.0142	0.0058	0.0147	0.0193	0.0119
2 quarters	0.0083	0.0085	0.0068	0.0070	0.0066	0.0060	0.0061	0.0062	0.0056
4 quarters	0.0065	0.0091	0.0067	0.0120	0.0104	0.0075	0.0102	0.0108	0.0092
8 quarters	0.0089	0.0114	0.0088	0.0268	0.0172	0.0131	0.0124	0.0146	0.0097

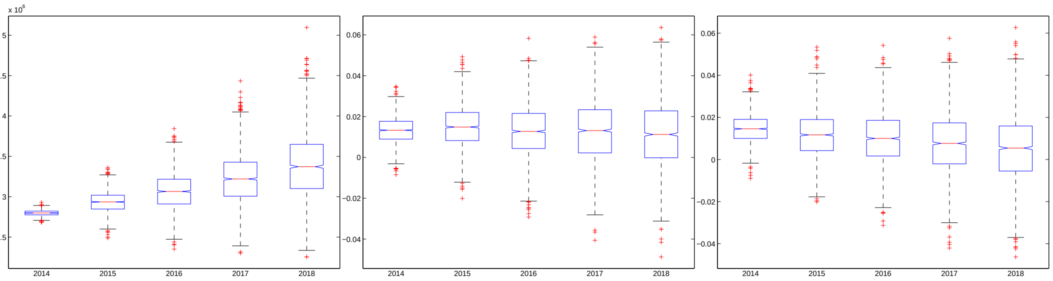
Notes: Entries are the root mean squared error of forecasts computed for a univariate model with four lags (AR), a vector autoregression model with four lags (VAR) and a random walk model (RW). Each estimation was done using Belgian data from 1980Q1 through the beginning of the forecast period, 2009Q4.

Finally, the application of a VAR for this purpose relies on the assumption of normality of the residuals. Bootstrapping techniques can, however, be applied on the residuals to avoid making the (restrictive) assumption of normality (see e.g. Burger et al., 2011; Medeiros, 2012). In particular, for k input variables and a horizon of T years, $k \times T$ random numbers are generated repeatedly until the generated and empirical distribution (using estimated parameters of the joint distribution of all input variables) are sufficiently close. The corresponding alternative results are illustrated in section 5 as well. For now a normal distribution is employed.

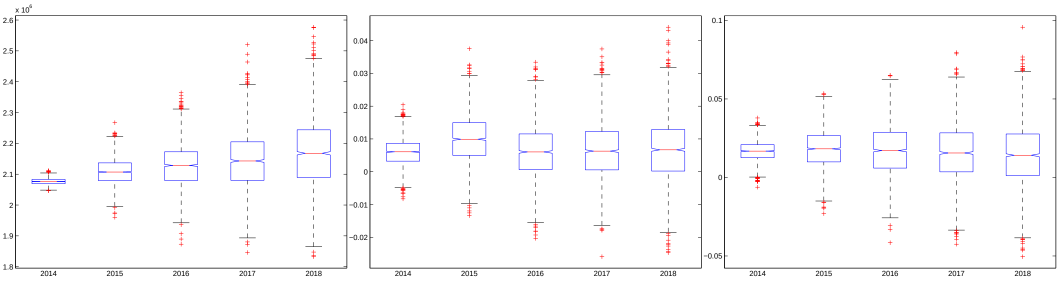
3.3 Fiscal Determinants

Given the simulated values for the macroeconomic variables, the fiscal policy component remains to be obtained in order to solve equation (2) forward. In particular, the future primary balances as a percentage of GDP need to be estimated. Doing so touches on two strands of literature. On one hand, an indicator of fiscal policy - often, the budget balance or primary balance - is regressed on the business cycle to infer the cyclical properties of the fiscal balance (see e.g. Gavin and Perotti, 1997; Galí and Perotti, 2003; Golinelli and Momigliano, 2009; Fatás and Mihov, 2012). To determine the fiscal stance's role in stabilizing the economy, it is advisable to distinguish between the automatic stabilizers inherent to public finances as legislated and discretionary fiscal policy, proxied by the cyclically adjusted budget balance. Nonetheless, both are of interest here.

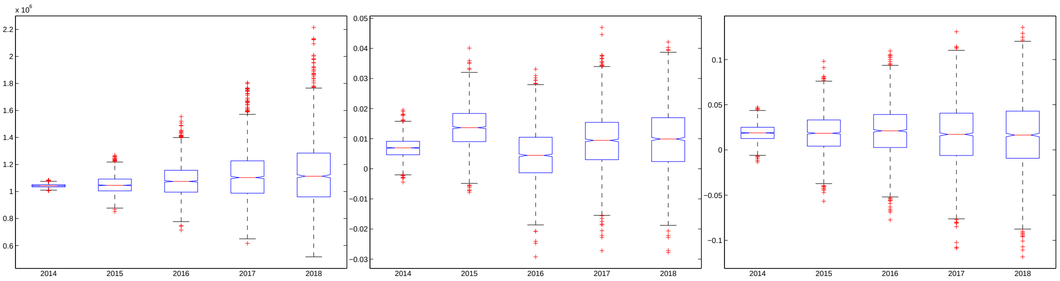
Closely related literature, on the other hand, estimates a fiscal reaction coefficient to test fiscal solvency. More specifically, Bohn (1995, 1998) introduced a type of model-based sustainability



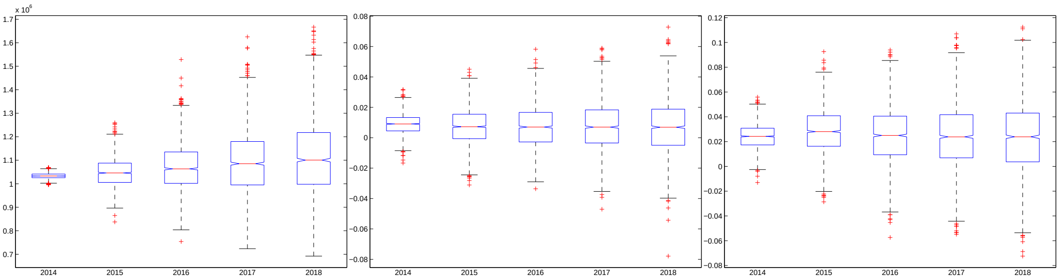
(a) Germany: real GDP **(b) Germany:** inflation **(c) Germany:** interest rate



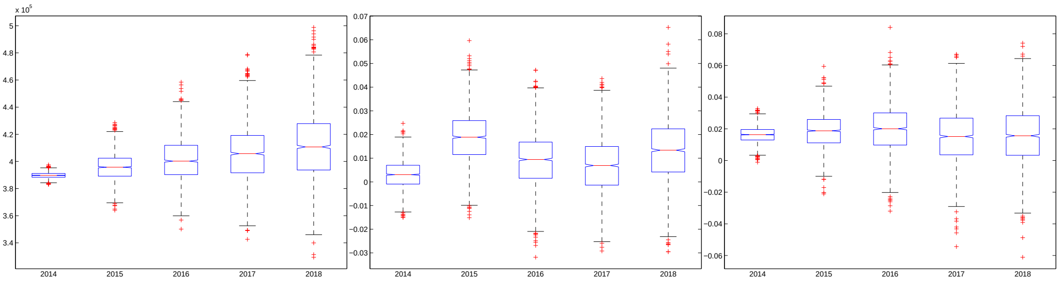
(d) France: real GDP **(e) France:** inflation **(f) France:** interest rate



(g) Italy: real GDP **(h) Italy:** inflation **(i) Italy:** interest rate



(j) Spain: real GDP **(k) Spain:** inflation **(l) Spain:** interest rate



(m) Belgium: real GDP **(n) Belgium:** inflation **(o) Belgium:** interest rate

Figure 1: Quarterly recursive VAR projections of X_t for 2014Q3-2018Q4. The boxplots are based on 2.000 period-by-period Monte Carlo simulations of the estimated model from its estimated covariance matrix, $\hat{\Omega}$, as specified in equation (5).

analysis accounting for the interest rate implications of uncertainty and risk aversion. To assess sustainability the primary balance is regressed on lagged debt and various controls. Finding that the reaction coefficient on lagged debt is positive and statistically significant is a sufficient condition for the intertemporal budget constraint (IBC) to hold. At the moment of writing, the test is the most common econometric test for sustainability. Other, more recent, applications of this approach include, for instance, Mendoza and Ostry (2008) and Mauro et al. (2013).

As in preceding probabilistic models, the significance of public debt in determining discretionary policy leads me to build on the model using lagged debt as introduced by Bohn (1998) to infer the fiscal policy component of the model. To obtain the fiscal determinants of the debt dynamics (i.e. the future primary balances), in what follows, I use an estimated fiscal reaction function to incorporate fiscal policy responses directly into debt projections. Specifically, due to the scarcity of budgetary data, an unbalanced panel of 28 countries over the period of 1995-2013 is used to estimate the following specification for each member state i in the panel:[11]

$$\begin{aligned} pb_{i,t} &= \beta_1 d_{i,t-1} + \beta_2 g_{i,t} + B_3 Z'_{i,t} + \varepsilon_{i,t}, \\ \text{with} \quad \varepsilon_{i,t} &= \eta_i + \upsilon_{i,t} \end{aligned} \tag{6}$$

where η_i denotes the country fixed effects and acts as an intercept. To account for the business cycle $g_{i,t}$, I use the output gap expressed as a percentage of potential GDP.[12] Note that the coefficient β_2 comprises the full fiscal stance, i.e. both the automatic stabilization entailed in public finances as well as the discretionary policy measures decided on given (actual) business cycle fluctuations. Subsection 3.3.4 isolates the discretionary policy. The set of controls covered by vector $Z_{i,t}$ is discussed later on in more detail.

3.3.1 Estimation Results

Table 2 shows the main estimation results following equation (6). The fixed effects (FE) model and the corresponding standard errors are estimated using a within-group transformation. Two additional tests relating to the consistency of the residuals were performed in order to check whether $\upsilon \sim \text{i.i.d.}(0, \Omega_\upsilon)$. First, the residuals are tested for autocorrelation. Given the annual macroeconomic time series used, within-country first-order autocorrelation of the error term is expected. Second, the Breusch-Pagan test and White test are used to test for heteroskedasticity in the residuals. Since heteroskedasticity and autocorrelation are simultaneously found to be present in the residuals, robust standard errors are constructed through clustering them by country.[13] In fact, by clustering along the cross section identifier, the resulting standard errors are completely robust to any kind of serial correlation and heteroskedasticity.[14]

---

[11] As for the non-fiscal determinants, the data structure of the panel, its sources and the descriptives are summarized in tables 13 and 14 in the appendix. In order to save space, only the core countries are included, as they are the focus of this paper. The 14 remaining countries of the periphery include: Bulgaria, Croatia, Cyprus, the Czech Republic, Estonia, Greece, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia.

[12] Quite a few studies calculate the output gap using a Hodrick-Prescott (HP) filter (see e.g. Tielens et al., 2014). The smoothing parameter λ of the HP-filter is then set at its standard value of 100 for data at the yearly frequency. Given the limited length of the available series, I prefer to put my trust in the output gap provided by the AMECO database itself instead of surmising the underlying trend.

[13] The Hausman test was used to test for fixed or random effects and supported the reported estimations. Its results as well as those of the residual specification tests can be obtained from the author upon request.

[14] Stock and Watson (2008) argued that with fixed effects the cluster-robust estimator is preferred if serial correlation is to be expected. Other parametric alternatives (e.g. heteroskedasticity-and-autocorrelation-robust (HAC-robust) estimators) often depend on the assumption of large T approximations. As illustrated by table 17 in the appendix, for the IV-2SLS regressions the differences in results nonetheless are limited. Moreover, the results in table 2 are found to be on the more cautious side of the spectrum.

Table 2: Static Fiscal Reaction Function

	FE				IV-2SLS			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$d_{i,t-1}$	0.05**	0.05**	0.03	0.05**	0.09***	0.06***	0.05**	0.07***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
$g_{i,t}$	0.53***	0.28***	0.26	0.28***	0.73***	0.34***	0.43***	0.33***
	(0.08)	(0.08)	(0.16)	(0.08)	(0.10)	(0.11)	(0.14)	(0.11)
$\pi_{i,t}$			0.28				0.25	
			(0.36)				(0.27)	
$r_{i,t}$			-0.07				-0.13	
			(0.18)				(0.14)	
$fri_{i,t}$				0.68*				0.64*
				(0.34)				(0.34)
Country FE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Time FE		0.000	0.000	0.000		0.000	0.000	0.000
N^o of Obs.	431	431	282	403	397	422	280	394
N^o of Instr.					5	3	5	4
Hansen test					0.006	0.187	0.762	0.281
Reduced F					166.79	430.13	121.92	361.37
Adjusted R^2	56.9%	67.3%	76.6%	70.7%	59.8%	68.7%	77.0%	72.3%

Notes: The dependent variable is the cyclically unadjusted primary budget balance ($pb_{i,t}$) of the respective countries. Country-clustered standard errors are noted in parentheses: * p<0.10, ** p<0.05, *** p<0.01. Since fixed effects are included, the table states the p-value corresponding to the F-test testing the null hypothesis that all country or time effects are jointly zero. For the instrumental variable regressions the p-values of the Sargan-Hansen tests for overidentifying restrictions are reported, as well as the F-statistic of the reduced form.

The inclusion of the simultaneous output gap in the model requires instrumenting. For example, one needs to be careful of reverse causality. Fiscal policy is bound to have an effect on output and thus $\mathbb{E}[\upsilon_{i,t}g_{i,t}] = 0$ will most likely not hold. Since there is no consensus on how to avoid the endogeneity problem, several approaches are considered. The primary set of instruments (V) for the cycle includes a measure of the cycle in the U.S. as well as the lags of the regressors. The model is estimated using the Anderson-Hsiao (1982) two-staged least squares (2SLS) levels estimator. At this point no assumptions are made about $\mathbb{E}[\upsilon\upsilon'|V] = \Omega_\upsilon$, except on its existence. Accordingly, the p-values of the Sargan-Hansen test for overidentifying restrictions for the full instrument set (i.e. the exogeneity assumption) are reported. Although less important in panel applications, since realizations of time-varying explanatory variables in different time periods are potential instruments, the tests give an indication of the validity of the employed instruments. This is a conclusion that is supported by the coefficients and F-statistic (≥ 10) of the reduced form model that regresses the endogenous variable on its instruments and exogenous counterparts, as suggested by Stock and Watson (2006).

In accordance with previous literature, the coefficient on the output gap is found to be positive and significant. On average, the primary balance is expected to increase by more than half a percent as the output gap as a percentage of potential GDP grows one percent larger (cf. model (5)). Allowing for jointly significant time effects serves a double purpose. It reduces the omitted-variable bias and makes the assumption that there is no correlation in the idiosyncratic disturbances across countries more likely to hold. Specifically, it increases the variance of the primary balance explained. Including time effects, nonetheless, results in a drop of the coefficient on the output gap, i.e. the overall stance of fiscal policy is found to be less countercyclical (cf. model (6)). Finally, the static models provide evidence for a limited response to previous evolutions in the public debt stock, pointing to a sustainable stance according to the definition of Bohn (1998).

It is argued that, in practice, the adjustment of fiscal policy does not take place within one time period (Galí and Perotti, 2003; Claeys, 2006).[15] As illustrated by equation (2), this effect would have an unwanted impact on the coefficient on the lagged debt, β_1 in equation (6). Furthermore, it would explain the residual autocorrelation in the static models. Therefore, estimating the dynamic counterparts of the former equations by including an autoregressive term of the dependent variable may tackle this omitted variable bias. The Least Square Dummy Variable (LSDV) estimator is commonly used to estimate fixed effects models as it is numerically, but not computationally, equivalent to a within group transformation. However, if the LSDV estimator is used to estimate a dynamic model, results become biased. Just as the FE ordinary least squares estimator, the results of the LSDV estimator may suffer from Nickell-bias in a dynamic setting (Nickell, 1981). In general, the lagged dependent variable is correlated with the fixed effects in the error term. Inconsistency occurs in panels with a large number of cross-sections over a fixed, small timeframe and increases as the autoregressive coefficient becomes larger. The LSDV estimator, nonetheless, offers a bias-corrected alternative (LSDVC) via the method proposed by Bruno (2005). Therefore, the following equation is estimated using that bias correction to obtain the results in table 3:

$$pb_{i,t} = \beta_1 pb_{i,t-1} + \beta_2 d_{i,t-1} + \beta_3 g_{i,t} + B_3 Z'_{i,t} + \varepsilon_{i,t} \tag{7}$$

Although Monte Carlo evidence points to the superiority of the LSDVC estimator over the generalized method of moments instrumental variable estimators (IV-GMM) in relatively narrow dynamic panels as applied here, the presence of endogeneity justifies a comparison of results. In order to do so, I use the difference IV-GMM estimator proposed by Arellano and Bond (1991), hereafter GMM-dif. The estimator instruments the differenced variables that are not strictly exogenous with all their available lags in levels, and uses additional instruments such as the U.S. output gap. Specifically, the two-step variant is estimated in combination with Windmeijer's (2005) robust standard errors in order to provide a finite sample correction and consistency in the presence of any pattern of heteroskedasticity and autocorrelation within the panels.[16]

Table 3, nonetheless, also contains the system IV-GMM (GMM-sys) estimations as developed by Blundell and Bond (1998). In comparison to the GMM-dif as initiated by Arellano and Bond (1991), they are potentially less affected by the weak instrument problem (i.e. scarcely correlated with the variables to be instrumented) with persistent data such as debt or the output gap.[17] Moreover, GMM-sys might be preferred over GMM-dif if the autocorrelation coefficient in the dynamic equation is close to unity (Verbeek, 2004), since lagged levels are poor instruments for first differences if the variables are close to a random walk. The instruments taken up in the GMM-sys are the lags of $g_{i,t}$, $d_{i,t-1}$ and $pb_{i,t-1}$ as well as the levels of the U.S. output gap.[18] The number of lags is collapsed and restricted to the second and third order (or earlier), as advised by Roodman (2009a, 2009b), to preserve a parsimonious model.

---

[15] The non-stationarity of the pb_t variable in the data at hand supports this argument.

[16] As for the static models, the p-values of the generalized Durbin-Watson autocorrelation test of the residuals are used for the LSDVC-models. The Arellano-Bond equivalents are recorded for the IV-GMM estimations. The order of the test depends on the model. For example, to check for AR(1) in levels, one has to look for AR(2) in the difference equations of the IV-GMM estimations.

[17] Using the two-step approach in combination with the corrected standard errors can furthermore make the two-step estimator more efficient than the one-step estimator, in particular for system GMM.

[18] Alternatively, (total) exports, imports, private consumption and exchange rates were considered as instruments.

Table 3: Dynamic Fiscal Reaction Function

	LSDVC				IV-GMM							
					GMM-diff				GMM-sys			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$pb_{i,t-1}$	0.61***	0.69***	0.67***	0.69***	0.33***	0.63***	0.40**	0.45***	0.42***	0.63***	0.57***	0.53***
	(0.04)	(0.05)	(0.06)	(0.05)	(0.07)	(0.14)	(0.19)	(0.12)	(0.10)	(0.09)	(0.11)	(0.11)
$d_{i,t-1}$	0.06***	0.04***	0.04***	0.05***	0.14***	0.09***	0.13***	0.11***	0.00	0.01	0.00	0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.03)	(0.04)	(0.03)	(0.01)	(0.01)	(0.01)	(0.00)
$g_{i,t}$	0.32***	0.13***	0.16*	0.11***	0.59***	0.40***	0.50***	0.30***	0.48***	0.16**	0.24**	0.20**
	(0.04)	(0.04)	(0.08)	(0.04)	(0.07)	(0.09)	(0.12)	(0.06)	(0.09)	(0.07)	(0.09)	(0.08)
$\pi_{i,t}$			0.23*	0.04			0.35				-0.28	
			(0.14)	(0.06)			(0.37)				(0.22)	
$r_{i,t}$			-0.08				0.19				0.19*	
			(0.12)				(0.16)				(0.09)	
$fri_{i,t}$				0.33**				-0.62				0.67**
				(0.16)				(0.72)				(0.26)
Country FE	0.000	0.000	0.000	0.000								
Time FE		0.000	0.000	0.000		0.031	0.602	0.001		0.000	0.000	0.000
N^o of Obs.	426	426	280	398	397	397	254	369	426	426	280	398
N^o of Instr.					7	11	11	12	14	18	18	20
Hansen J-test					0.310	0.315	0.977	0.214	0.157	0.163	0.759	0.352
Reduced F					79.48	65.36	95.09	58.49	21.00	94.12	132.23	45.08
Goodness-of-fit	73.0%	80.8%	85.4%	83.3%	24.3%	48.1%	20.7%	32.4%	51.0%	71.4%	72.5%	69.5%

Notes: The dependent variable is the cyclically unadjusted primary budget balance ($pb_{i,t}$) of the respective countries. Standard errors are noted in parentheses: * $p<0.10$, ** $p<0.05$, *** $p<0.01$. In columns (1)-(4) bootstrapped standard errors following the bias-corrected alternative by Bruno (2005) are reported. For the IV-GMM models in columns (5)-(12) two-step Windmeijer's (2005) robust standard errors are reported. In the case that fixed effects are present the table states the p-value corresponding to the F-test testing the null hypothesis that all country or time effects are jointly zero. For the instrumental variable regressions the p-values of the Sargan-Hansen tests for overidentifying restrictions are reported, as well as the F-statistic of the reduced form. The goodness-of-fit is the squared correlation coefficient between the actual and predicted values of the primary balance (see e.g. Bloom et al., 2007).

The various dynamic models' estimations in table 3 show that static results on the fiscal stance still stand. The coefficient on the output gap, nonetheless, decreases considerably. Similarly, despite the fact that the coefficient on the lagged debt is more significant, its size varies notably depending on the approach. In the GMM-sys model the reaction to public debt, nonetheless, is non-existent. Which model is then to be preferred? Undoubtedly, instrumenting is important for inferring on the actual response to the business cycle. Furthermore, in comparison to the GMM-dif model, the GMM-sys model is not only more efficient estimation-wise, but its results also show a higher goodness-of-fit. Furthermore, the GMM-dif model residuals clearly deviate from white noise (cf. the CumbyHuizinga test).

Regardless discretionary fiscal policy is not only characterized by the evolution of public debt during previous periods, as suggested by the aforementioned stochastic projection models. For example, the output gap, macro-financial factors (such as real exchange rates, interest rates, asset prices and natural resource rents) and demographic and institutional factors (such as old-age dependency ratios, quality of institutions, fiscal rules and IMF-supported stabilization programmes) are found to have a significant effect on changes in the cyclically adjusted primary budget balance as well (Cevik and Teksoz, 2014). Theofilakou and Stournaras (2012) also look at the interaction with financial markets. Afonso and Hauptmeier (2009) look at institutional drivers, such as fiscal rules and the degree of decentralization. In the same vein, Claeys et al. (2008), in turn, go deeper into the fiscal federalism aspects based on the case of Germany. Hence, estimating a panel data model that incorporates such variables as controls (Z_t) is worthwhile.

Given the importance of interest rates and inflation as non-fiscal determinants, I first test for their relevance using the third model of each estimation method. In general, both inflation and interest rates seem to have little influence at the macro level. The long-term interest rate, as defined by the EMU convergence criteria, is not found to be significant in any of the models but the GMM-sys model. Next, only the LSDVC-model shows evidence of fiscal drag through bracket creep. In other words, using this broad specification I found little evidence that inflation pushes income into higher progressive tax brackets and consequently increases government revenues.

Including a measure of the institutional guarantees for fiscal discipline in the static models, on the other hand, does seem to have a favorable impact on the primary balance. In particular, the fiscal rule index designed by the European Commission measures the presence, enforceability and strictness of the borrowing constraints of the member states. Incorporating the index into the models results in findings that are in accordance with earlier findings on the matter (e.g. Afonso and Hauptmeier (2009) who rely on LSDVC estimates). Specifically, the presence of stronger fiscal rules is found to be effective, i.e. by improving primary balances. Interestingly, in the static models the effect goes hand in hand with a significant effect of lagged debt. The dynamic LSDVC model also finds a significant effect of both the lagged debt and institutional rules, albeit smaller. In the GMM-dif model the significance of the index, however, disappears.[19] Despite the lagged debt losing its significance, the final dynamic instrumented model (GMM-sys) of table 3 does find a positive and significant coefficient for the index as well. Therefore, the empirical evidence suggests that the politically driven enforcement of institutional rules can counter countries' gloomy public finances.

Employing the output gap in levels results in inferences on the impact of the position of the economy vis-á-vis its potential level and the distance from it. Alternatively, one could include the rate of economic growth or a similar measure, such as the change in the output gap or the difference between actual and trend growth. Doing so shifts the focus to whether the economy is in an upturn

---

[19] A possible explanation could be the lack of variation in the variable itself, which makes it harder for the models to grasp its actual impact. This is a problem often observed with the use of indices. Yet, this does not seem to trouble the other estimation methods. Therefore, a more likely and reasonable explanation would be the shortcomings of the method itself.

or a downturn and the respective intensity thereof.[20] Tables 17 and 18 - for succinctness, appended at the back - contain the estimation results for when the GDP growth rate is included instead. By doing so, the overall explanatory power of the static models drops slightly, since the growth elasticity is then found to be smaller than the elasticity of the economy vis-á-vis its potential level. In addition, the response to debt is slightly smaller. Despite the presence of lower $d_{i,t-1}$ coefficients in the dynamic models as well, the difference in $g_{i,t}$ coefficients becomes negligible for some models and possibly even larger for GDP growth than for the output gap.

Finally, in tables 4 and 5 the panel is subdivided into two subsets: the core and peripheral European countries (see footnote 11).[21] When doing so, the responsiveness to economic fluctuations is generally found to be larger in the core countries. This fact is duly taken into account in the analysis of fiscal discipline that follows. Data limitations prevent the formation of any solid conclusions about the peripheral countries.

3.3.2 Analysis at the Component Level

Given that the budget balance is best subdivided according to fiscal revenues and public expenditures in order to identify the cyclical component of the budget balance (based on the budgetary sensitivities or elasticities as a result of automatic stabilizers), it is worthwhile to do the same for the cyclically unadjusted primary budget balance used for the estimation of the discretionary fiscal determinants (see e.g. Claeys, 2008). It may be the case that fiscal policy adjustments to macro-financial, demographic and institutional factors might differ significantly for revenues and expenditures.

Splitting up $pb_{i,t}$ into its components

$$pb_{i,t} = t_{i,t} - pg_{i,t} \tag{8}$$

where $t_{i,t}$ denotes the cyclically unadjusted public revenues as a percentage of GDP of country i at time t and $pg_{i,t}$ denotes the corresponding primary expenditures as a percentage of GDP. Broadly the following two equations can thus be estimated separately:

$$t_{i,t} = \beta_1^t t_{i,t-1} + \beta_2^t d_{i,t-1} + B_3^t Z'_{i,t-1} + \varepsilon_{i,t}^t \tag{9}$$

$$pg_{i,t} = \beta_1^g pg_{i,t-1} + \beta_2^g d_{i,t-1} + B_3^g Z'_{i,t-1} + \varepsilon_{i,t}^g, \tag{10}$$

where $\varepsilon_{i,t}^j = \eta_i^j + \upsilon_{i,t}^j$ with $j \in \{t, g\}$. The estimation results for the European core countries are summarized in tables 6 and 7. According to expectations, the rate of public spending is found to be negatively related to the output gap. In other words, as the state of the economy worsens, expenditures as a percentage of GDP are bound to increase, and vice versa. Despite the relatively small automatic stabilizers (e.g. unemployment payments) and thus small elasticity of nominal expenditures, the elasticity of the rate is significant as a result of the effect in its denominator. The negative sign on inflation follows this reasoning. As economies slow down, expenditures do not only grow as a percentage of GDP, but inflation is generally lower. For public revenues the effects are much less outspoken as there is a considerable output elasticity of nominal revenues in the numerator as well. Finally, fiscal rules are again found to be effective. The strength of the imposed fiscal rules is associated with decreased expenditures, while only the GMM-sys model points to a positive and significant impact on the revenue side of the budget.

---

[20] For a more comprehensive overview of the possible model setups for gauging the cyclical reaction of fiscal policies see Golinelli and Momigliano (2009).

[21] The last static model including the FRI is also shown in table 19 in the appendix.

Table 4: Dynamic Fiscal Reaction Function: Core Countries

	LSDVC				IV-GMM							
					GMM-diff				GMM-sys			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$pb_{i,t-1}$	0.59***	0.72***	0.73***	0.72***	0.39***	0.43***	0.49***	0.45***	0.31***	0.57***	0.55***	0.52***
	(0.05)	(0.06)	(0.07)	(0.06)	(0.06)	(0.14)	(0.14)	(0.12)	(0.08)	(0.13)	(0.09)	(0.12)
$d_{i,t-1}$	0.06***	0.04***	0.04**	0.04***	0.14***	0.10***	0.08***	0.09***	0.01**	0.01*	0.03*	0.01**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.03)	(0.03)	(0.01)	(0.01)	(0.02)	(0.01)
$g_{i,t}$	0.55***	0.16*	0.18**	0.20**	0.81***	0.60***	0.39***	0.48***	0.84***	0.40**	0.36*	0.28
	(0.06)	(0.08)	(0.09)	(0.09)	(0.07)	(0.13)	(0.13)	(0.12)	(0.10)	(0.16)	(0.17)	(0.16)
$\pi_{i,t}$			0.09	0.12			-0.18				-0.39**	
			(0.15)	(0.16)			(0.32)				(0.18)	
$r_{i,t}$			-0.08				0.24				0.08	
			(0.12)				(0.17)				(0.06)	
$fri_{i,t}$				0.30				-0.47				0.33*
				(0.23)				(0.89)				(0.17)
Country FE	0.000	0.000	0.000	0.000								
Time FE		0.000	0.000	0.000		0.301	0.035	0.156		0.103	0.043	0.001
N^o of Obs.	250	250	246	236	235	235	231	221	250	250	246	236
N^o of Instr.					7	11	11	12	14	18	18	20
Hansen J-test					0.917	0.377	0.453	0.214	0.311	0.341	0.854	0.987
Reduced F					64.12	50.92	44.70	40.62	60.59	93.25	106.61	115.62
Goodness-of-fit	78.8%	87.7%	87.6%	88.2%	29.9%	37.7%	51.2%	40.4%	56.9%	74.9%	73.9%	74.0%

Notes: The dependent variable is the cyclically unadjusted primary budget balance ($pb_{i,t}$) of the respective countries. Standard errors are noted in parentheses: * $p<0.10$, ** $p<0.05$, *** $p<0.01$. In columns (1)-(4) bootstrapped standard errors following the bias-corrected alternative by Bruno (2005) are reported. For the IV-GMM models in columns (5)-(12) two-step Windmeijer's (2005) robust standard errors are reported. In the case that fixed effects are present the table states the p-value corresponding to the F-test testing the null hypothesis that all country or time effects are jointly zero. For the instrumental variable regressions the p-values of the Sargan-Hansen tests for overidentifying restrictions are reported, as well as the F-statistic of the reduced form. The goodness-of-fit is the squared correlation coefficient between the actual and predicted values of the primary balance (see e.g. Bloom et al., 2007).

Table 5: Dynamic Fiscal Reaction Function: Peripheral Countries

	LSDVC				IV-GMM							
					GMM-diff				GMM-sys			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$pb_{i,t-1}$	0.45***	0.59***	-0.43	0.55***	0.21*	0.49*	0.59	0.43***	0.34	0.44*	2.14***	0.58***
	(0.07)	(0.08)	(0.30)	(0.08)	(0.12)	(0.29)	(1.44)	(0.16)	(0.22)	(0.22)	(0.49)	(0.19)
$d_{i,t-1}$	0.08***	0.05**	0.04	0.06***	0.12**	0.04	0.02	0.13***	-0.02*	-0.02*	-0.05	-0.01
	(0.02)	(0.02)	(0.18)	(0.02)	(0.05)	(0.07)	(0.40)	(0.05)	(0.01)	(0.01)	(0.07)	(0.01)
$g_{i,t}$	0.26***	0.14*	0.59	0.12*	0.38***	0.25*	0.22	0.25***	0.23*	0.13	-0.30	-0.00
	(0.05)	(0.07)	(0.60)	(0.07)	(0.09)	(0.14)	(1.59)	(0.08)	(0.12)	(0.17)	(0.45)	(0.11)
$\pi_{i,t}$			-0.32	0.07			0.55				-0.93	
			(0.78)	(0.07)			(0.95)				(0.89)	
$r_{i,t}$			-0.24				-0.21				0.78	
			(1.06)				1.84				(0.89)	
$fri_{i,t}$				0.41				-1.90				0.35
				(0.29)				(1.29)				(0.42)
Country FE	0.000	0.000	0.167	0.000								
Time FE		0.000	0.620	0.000		0.311	0.475	0.086		0.002	0.007	0.000
N^o of Obs.	176	176	34	162	162	162	23	148	176	176	34	162
N^o of Instr.					7	11	11	12	14	18	18	20
Hansen J-test					0.425	0.573	1.000	0.391	0.299	0.386	1.000	0.950
Reduced F					89.37	119.40	5.73	146.53	35.53	82.81	935.78	393.36
Goodness-of-fit	53.2%	62.6%	75.0%	70.0%	6.2%	38.4%	3.2%	6.2%	29.4%	44.7%	21.0%	54.3%

Notes: The dependent variable is the cyclically unadjusted primary budget balance ($pb_{i,t}$) of the respective countries. Standard errors are noted in parentheses: * p<0.10, ** p<0.05, *** p<0.01. In columns (1)-(4) bootstrapped standard errors following the bias-corrected alternative by Bruno (2005) are reported. For the IV-GMM models in columns (5)-(12) two-step Windmeijer's (2005) robust standard errors are reported. In the case that fixed effects are present the table states the p-value corresponding to the F-test testing the null hypothesis that all country or time effects are jointly zero. For the instrumental variable regressions the p-values of the Sargan-Hansen tests for overidentifying restrictions are reported, as well as the F-statistic of the reduced form. The goodness-of-fit is the squared correlation coefficient between the actual and predicted values of the primary balance (see e.g. Bloom et al., 2007).

Table 6: Reaction Functions at the Component Level: Total Primary Expenditures

	Static						Dynamic					
	FE			IV-2SLS			LSDVC			IV-GMM-sys		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$pg_{i,t-1}$							0.61***	0.67***	0.66***	1.15***	1.06***	1.04***
							(0.07)	(0.06)	(0.06)	(0.06)	(0.11)	(0.08)
$d_{i,t-1}$	-0.01	-0.01	0.02	-0.03	0.00	0.02	-0.05**	-0.03**	-0.03*	-0.11***	-0.05	-0.03
	(0.02)	(0.03)	(0.03)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.04)	(0.05)	(0.05)
$g_{i,t}$	-0.98***	-0.55***	-0.70***	-1.36***	-0.45***	-0.73***	-0.63***	-0.28**	-0.30**	-0.41***	-0.31	-0.09
	(0.15)	(0.18)	(0.23)	(0.32)	(0.16)	(0.19)	(0.12)	(0.12)	(0.13)	(0.11)	(0.33)	(0.13)
$\pi_{i,t}$		-0.64			-0.49			-0.41**	-0.48**		0.17	
		(0.58)			(0.37)			(0.20)	(0.20)		(0.76)	
$r_{i,t}$		0.02			0.02			0.13			0.04	
		(0.28)			(0.25)			(0.16)			(0.23)	
$fri_{i,t}$			-0.75*			-0.75***			-0.37			-0.28
			(0.40)			(0.34)			(0.31)			(0.74)
Country FE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000			
Time FE		0.001	0.000		0.000	0.000		0.006	0.008		0.000	0.000
N^o of Obs.	252	248	238	238	248	238	252	248	238	252	248	238
N^o of Instr.				5	5	4				14	18	20
Hansen test				0.297	0.312	0.332				0.238	0.427	0.580
Reduced F				94.70	69.56	143.73				55.25	45.49	67.28
Goodness-of-fit	83.1%	86.8%	86.7%	81.6%	86.3%	86.3%	90.1%	91.9%	92.2%	74.1%	83.2%	86.7%

Notes: The dependent variable is the cyclically unadjusted primary expenditures as a percentage of GDP ($pg_{i,t}$) of the respective countries. Standard errors are noted in parentheses: * p<0.10, ** p<0.05, *** p<0.01. In columns (1)-(6) country-clustered standard errors are computed to correct for heteroskedasticiy and autocorrelation in the residuals. In columns (7)-(9) bootstrapped alternatives following the bias-correction by Bruno (2005) are reported. For the IV-GMM models in columns (10)-(12) two-step Windmeijer's (2005) robust standard errors are reported. In the case that fixed effects are included, the table states the p-value corresponding to the F-test testing the null hypothesis that all country or time effects are jointly zero. For the instrumental variable regressions the p-values of the Sargan-Hansen tests for overidentifying restrictions are reported, as well as the F-statistic of the reduced form. The goodness-of-fit is the squared correlation coefficient between the actual and predicted values of the primary balance (see e.g. Bloom et al., 2007).

Table 7: Reaction Functions at the Component Level: Total Revenues

	Static						Dynamic					
	FE			IV-2SLS			LSDVC			IV-GMM-sys		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$t_{i,t-1}$							0.80***	0.80***	0.81***	0.97***	0.98***	0.97***
							(0.07)	(0.06)	(0.06)	(0.01)	(0.02)	(0.01)
$d_{i,t-1}$	0.04**	0.02	0.04**	0.04**	0.04*	0.04**	0.01**	0.00	0.00	0.02***	0.02*	0.02***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
$g_{i,t}$	0.04	-0.03	0.07	0.13*	0.06	0.08	-0.03	-0.02	0.01	-0.01	0.05	0.02
	(0.08)	(0.15)	(0.07)	(0.07)	(0.09)	(0.08)	(0.07)	(0.05)	(0.05)	(0.03)	(0.06)	(0.04)
$\pi_{i,t}$		0.17			0.05			0.03			0.10	
		(0.11)			(0.10)			(0.09)			(0.12)	
$r_{i,t}$		-0.17			-0.11			-0.02			-0.11*	
		0.20			(0.10)			(0.07)			(0.05)	
$fri_{i,t}$			-0.29			-0.26			0.01			0.25**
			(0.35)			(0.32)			(0.14)			(0.12)
Country FE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000			
Time FE		0.006			0.000	0.000		0.042	0.053			
N^o of Obs.	252	248	238	238	248	238	252	248	238	252	248	238
N^o of Instr.				5	5	4				14	14	16
Hansen test				0.458	0.403	0.237				0.340	0.157	0.546
Reduced F				94.70	243.49	146.32				52.77	12.03	108.33
Goodness-of-fit	96.1%	96.9%	96.5%	96.4%	96.6%	96.6%	98.2%	98.5%	98.4%	97.1%	97.0%	97.4%

Notes: The dependent variable is the cyclically unadjusted public revenues as a percentage of GDP ($t_{i,t}$) of the respective countries. Standard errors are noted in parentheses: * $p<0.10$, ** $p<0.05$, *** $p<0.01$. In columns (1)-(6) country-clustered standard errors are computed to correct for heteroskedasticiy and autocorrelation in the residuals. In columns (7)-(9) bootstrapped alternatives following the bias-correction by Bruno (2005) are reported. For the IV-GMM models in columns (10)-(12) two-step Windmeijer's (2005) robust standard errors are reported. In the case that fixed effects are included, the table states the p-value corresponding to the F-test testing the null hypothesis that all country or time effects are jointly zero. For the instrumental variable regressions the p-values of the Sargan-Hansen tests for overidentifying restrictions are reported, as well as the F-statistic of the reduced form. The goodness-of-fit is the squared correlation coefficient between the actual and predicted values of the primary balance (see e.g. Bloom et al., 2007).

3.3.3 Fiscal Fatigue

As mentioned before, Bohn (1998) showed that a sufficient condition for fiscal sustainability is that a country's fiscal reaction function is characterised by primary balances that rises at least linearly with past debt. Nonetheless, it has been argued that it cannot be that primary surpluses would always keep pace with rising debt. In extremis this would require surpluses that exceed GDP. Instead, Ghosh et al. (2013a, 2013b) and Medeiros, 2012 argue that "fiscal fatigue" sets in after the public debt stock exceeds a particular debt ratio, whereby it becomes progressively more difficult to keep increasing the primary surplus by raising taxes or lowering non-interest expenditures.

In order to test for this I re-estimate model (12) non-linearly for both the full sample as the

Table 8: Non-linear Fiscal Reaction Function (IV-GMM-sys)

	Full			*Core*				
	$\underline{d} = \bar{d} =$ 70%	quadr.	cubic	$\underline{d} = \bar{d} =$ 75%	$\underline{d} = \bar{d} =$ 40%	$\bar{d} = 80\%$ $\underline{d} = 40\%$	quadr.	cubic
$pb_{i,t-1}$	0.56***	0.57***	0.64***	0.50***	0.55***	0.53**	0.51***	0.47*
	(0.12)	(0.12)	(0.19)	(0.15)	(0.17)	(0.19)	(0.14)	(0.24)
$d_{i,t-1}$		-0.01	-0.11*				0.00	0.03
		(0.03)	(0.06)				(0.02)	(0.11)
$< \underline{d}$	-0.00			0.01**	-0.00	0.01		
	(0.01)			(0.01)	(0.04)	(0.04)		
$\underline{d} < . < \bar{d}$						0.02**		
						(0.01)		
$\bar{d} <$	0.01			0.01	0.01**	0.01		
	(0.02)			(0.01)	(0.01)	(0.01)		
$d^2_{i,t-1}$		0.00	0.00*				0.00	-0.00
		(0.00)	(0.00)				(0.00)	(0.00)
$d^3_{i,t-1}$			-0.00*					0.00
			(0.00)					(0.00)
$g_{i,t}$	0.20**	0.22***	0.14	0.32	0.27	0.31	0.32*	0.38
	(0.08)	(0.08)	(0.10)	(0.23)	(0.16)	(0.21)	(0.17)	(0.32)
$fri_{i,t}$	0.56*	0.65**	0.81**	0.23	0.35*	0.19	0.38	0.32
	(0.27)	(0.24)	(0.32)	(0.25)	(0.17)	(0.27)	(0.42)	(0.37)
Time FE	0.000	0.000	0.000	0.003	0.001	0.004	0.005	0.163
N^o of Obs.	398	398	398	236	236	236	236	236
N^o of Instr.	20	20	20	20	20	20	20	20
Hansen test	0.251	0.164	0.068	0.981	0.978	0.972	0.976	0.964
Reduced F	45.08	45.08	45.08	115.62	115.62	115.62	115.62	115.62
Adjusted R^2	71.7%	72.1%	68.0%	73.2%	74.5%	73.8%	74.0%	73.3%

Notes: The dependent variable is the cyclically unadjusted primary budget balance ($pb_{i,t}$) of the respective countries. Standard errors are noted in parentheses: * p<0.10, ** p<0.05, *** p<0.01. All specifications were estimated using IV-GMM-sys. Two-step Windmeijer's (2005) robust standard errors are reported. Additionally, the p-values of the Sargan-Hansen tests for overidentifying restrictions are reported, as well as the F-statistic of the reduced form. The goodness-of-fit is the squared correlation coefficient between the actual and predicted values of the primary balance (see e.g. Bloom et al., 2007).

subset of core countries. In particular, the coefficient of lagged debt is made contingent on the debt rate itself by including interaction terms. Alternatively, quadratic and cubic specifications are tested. The results are included in table 8.

Given the insignificant and negligible coeffecient on debt for the full sample in table 3 unsurprisingly no significant effect is found here either. Only a cubic function seems to point towards its presence. To facilitate the interpretation of the equation it is fitted to the data in figure 12 in the appendix. The fatigue would kick in as the debt rate approaches 130%, much later than the range of 80-100% of earlier studies. Nonethless, at these levels the number of observations is limited, thereby making the estimation unstable. The effect moreover disappears for the subset of core European countries. The small effect initially found for the core countries in table 4 does show non-linearities in case of the interaction equations. Overall, the evidence on fiscal fatigue, however, is limited.

3.3.4 A Break Down of the Fiscal Stance

Denote the cyclically adjusted budget balance of country i in period t, expressed as a percentage of its GDP, as $capb_{i,t}$ and the automatic stabilizers as $as_{i,t}$. Since

$$pb_{i,t} \equiv capb_{i,t} + as_{i,t} \tag{11}$$

holds by definition, the aforementioned coefficients on $g_{i,t}$ comprised both automatic stabilizers and discretionary policy. Even though equation (6) is appropriate for model-based sustainability analysis and gets us a long way, it seems worthwhile to break down fiscal stance further for the current application. After all, incorporating lagged debt is insufficient to fully describe discretionary policy.[22] Therefore, instead of equation (6), I now estimate:

$$\begin{aligned} capb_{i,t} &= \beta_1 d_{i,t-1} + \beta_2 g_{i,t} + B_3 Z'_{i,t} + \varepsilon_{i,t} \\ \text{with} \quad \varepsilon_{i,t} &= \eta_i + \upsilon_{i,t} \end{aligned} \tag{12}$$

Equation (12) is thus designed to only capture discretionary policy. Consequently, estimating equation (12) allows me to single out discretionary policy more correctly in the stochastic debt projections. The CABB can thus be identified separately, allowing for the analysis of the MTOs imposed on it.

As shown in table 9, if there is any impact of output - in addition to automatic stabilizers - it is expected to be negative. In other words, discretionary policy is found to be procyclical on average, especially in peripheral countries. Furthermore, the previous period debt rate plays a significant role in determining discretionary policy in core European countries. As the debt rate grows larger, discretionary public finances become stricter. In the same vein, instrumenting to overcome endogeneity proves the effectiveness of fiscal rules in constraining discretionary policy.

Finally, as a robustness check, the covariance of the budget balance with the business cycle driving the cyclical components can be compared to the budget sensitivities or semi-elasticities used by, for example, the European Commission for computing structural balances (see e.g. Girouard and André, 2005; Larch and Turrini, 2009; Mourre et al., 2013; Mourre et al., 2014). The values found above are sufficiently close to the EU-28 averages found by the E.C., therefore bolstering trust in the empirical findings.

---

[22] Carnot and de Castro (2015), nonetheless, derive the methodological difference between the structural (primary) balance and the actual discretionary fiscal effort. Overall, the differences are found to be rather small in practice.

Table 9: Cyclically Adjusted Fiscal Reaction Function

	LSDVC			IV-GMM-sys		
	Core	*Per.*	*Full*	*Core*	*Per.*	*Full*
$capb_{i,t-1}$	0.68***	0.53***	0.65***	0.62***	0.49***	0.60***
	(0.07)	(0.08)	(0.05)	(0.12)	(0.21)	(0.13)
$d_{i,t-1}$	0.04**	0.08***	0.05***	0.02**	0.00	-0.00
	(0.02)	(0.03)	(0.01)	(0.01)	(0.01)	(0.01)
$g_{i,t}$	-0.07	-0.13	-0.12***	0.07	-0.29**	-0.12*
	(0.09)	(0.08)	(0.04)	(0.22)	(0.10)	(0.07)
$\pi_{i,t}$	0.22	0.12*	0.11*	-0.41	-0.00	0.06
	(0.17)	(0.07)	(0.06)	(0.28)	(0.13)	(0.09)
$fri_{i,t}$	0.38	0.25	0.33*	0.25	1.05	0.42**
	(0.24)	(0.32)	(0.18)	(0.20)	(1.22)	(0.20)
Country FE	0.000	0.000	0.000			
Time FE	0.000	0.342	0.000	0.000	0.000	0.000
N^o of Obs.	236	154	390	236	154	390
N^o of Instr.				20	20	20
Hansen test				0.958	0.999	0.308
Reduced F				114.29	36.38	26.47
Adjusted R^2	82.4%	67.9%	79.9%	68.9%	43.2%	68.8%

Notes: The dependent variable is the cyclically adjusted primary budget balance ($pb_{i,t}$) of the respective countries. Standard errors are noted in parentheses: * $p<0.10$, ** $p<0.05$, *** $p<0.01$. In columns (1)-(3) bootstrapped standard errors following the bias-corrected alternative by Bruno (2005) are reported. For the IV-GMM models in columns (4)-(6) two-step Windmeijer's (2005) robust standard errors are reported. In the case that fixed effects are present the table states the p-value corresponding to the F-test testing the null hypothesis that all country or time effects are jointly zero. For the instrumental variable regressions the p-values of the Sargan-Hansen tests for overidentifying restrictions are reported, as well as the F-statistic of the reduced form. The goodness-of-fit is the squared correlation coefficient between the actual and predicted values of the primary balance (see e.g. Bloom et al., 2007).

3.4 Stochastic Projections of EMU Public Finances

In order to obtain the projected paths of public finances, random vectors of shocks to the non-fiscal determinants of debt dynamics are generated for each projection year and these, together with the estimated coefficients of the VAR model, are used to project the (non-fiscal) macroeconomic variables into the future. The path of the debt-to-GDP ratio corresponding to each sequence of simulated shock vectors (i.e. one vector per projection year) is then obtained through the standard debt evolution equation, which relates the debt ratio in a certain year to the primary balance and the debt ratio of the previous year.

The above described algorithm will produce as many debt paths as the number of simulated shock constellations. In particular, I perform 2.000 period-by-period Monte Carlo simulations of the estimated model using its estimated covariance matrix. Hence, based on the stochastic realizations of key debt determinants and accounting for their variances and covariances structure, the entire distribution of debt stocks over a medium-term horizon can be constructed. Consequently, this approach will also allow for the application of Value-at-Risk measures of fiscal sustainability (see e.g. Barnhill and Kopits, 2003; EC, 2011; van Ewijk et al., 2013) as pioneered in financial economics (Jorion, 2007). Moreover, the algorithm can incorporate any number of distributional assumptions on fat tails and asymmetries, though the default assumption is a normal distribution.

The simulated paths for the five European countries their end-of-year public debt rates that can be expected to evolve over the period from 2014 to 2018, are displayed in figure 2. The different colors of the shaded areas portray the different deciles of the projections, which are based on 2.000 period-by-period Monte Carlo simulations of the estimated probabilistic model (as illustrated in figure 1). A more detailed account of the deciles is given in table 20 in the appendix. Figure 3, moreover, plots the histograms for the public debt stock as a percentage of GDP at the end of 2018. Additionally, as a way of illustration, it also plots the movement in the distribution of the stochastic debt rate simulations over the period of 2014-2018 for the case of Belgium.

For the benchmark simulation the fiscal reaction model (12) from table 4 was employed. After all, given the member states considered in the analysis, using the simulations for the core countries is more appropriate. The required output gap expressed as a percentage of potential GDP is constructed by using a Hodrick-Prescott (HP) filter. The smoothing parameter λ of the HP-filter is set at its standard value 1600 for data at the quarterly frequency. Next to its reasonable goodness-of-fit, model (12) can be considered the more cautious option as policymakers' reactions to public debt evolutions and the output gap remain limited.[23] Nevertheless, other alternatives are discussed in subsection 5.2 as well.

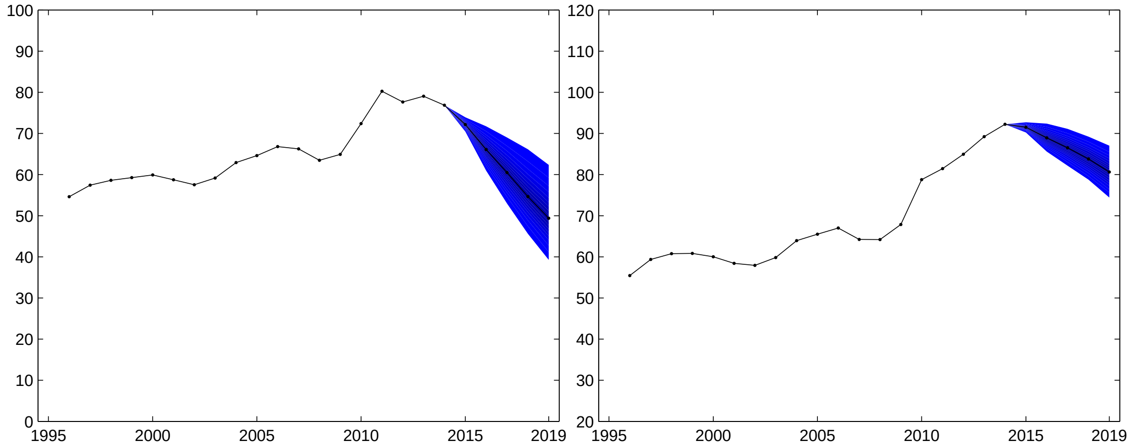
4 Analysis of Fiscal Discipline

The design of efficient and effective borrowing constraints has been the center of debate for several decades. In practice, long-term fiscal sustainability indicators are the main drivers for fiscal rules, but they offer little to no operational goals for the short-run. Therefore, shedding light on, for instance, the short to medium-term probability that constraints are adhered to will provide useful guidelines for policy makers in the process of implementing or revising such measures.

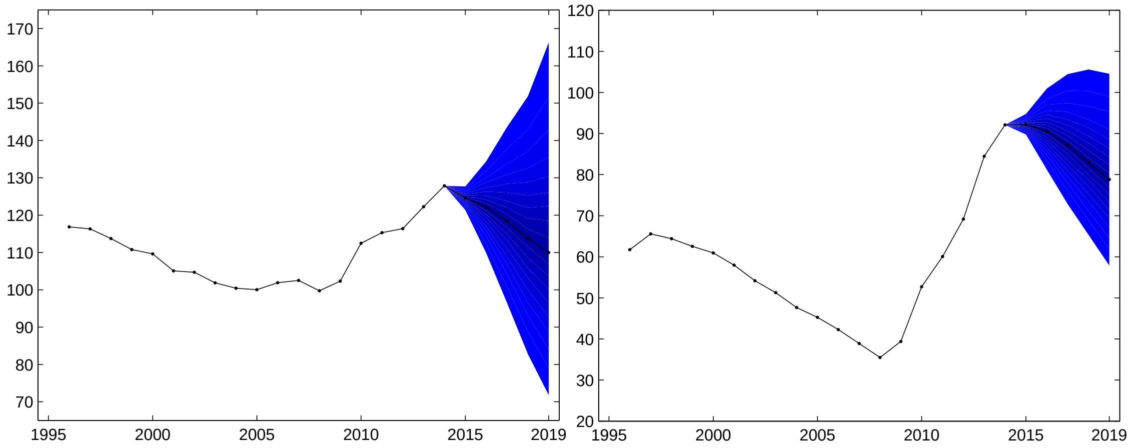
In particular, using the model one can make several inferences about the implied risk for fiscal discipline. First, along the lines set out by Value-at-Risk analysis, the likelihood of certain future debt scenarios and the upward risk of the public debt stock can be quantified (section 4.1). Second, the model can be simulated to find the uncertainty that would remain under the assumption that member states closely stick to the Stability Programmes' targets. Specifically, one can compute the ceteris paribus probability that member states will be able to adhere to their objectives. Or, complimentarily, it can give the distribution of the fiscal adjustment necessary to restore stability. Similarly, one can compute the probability that targets set by the European Commission, such as the debt brake rule and MTO adjustment path, are achieved. Thus, the model results in a reliable measure of whether the rules are attainable under the variances and covariances structure of the macroeconomic variables (section 4.2). The resulting infringement risk measures would allow policy makers to come to recommendations as to whether the budgetary targets are overly strict or, in the opposite case, insufficiently stringent. Third, the model and the resulting measures can be extended to include policy related uncertainty as well as uncertainty from macroeconomic variables (section 4.3).

---

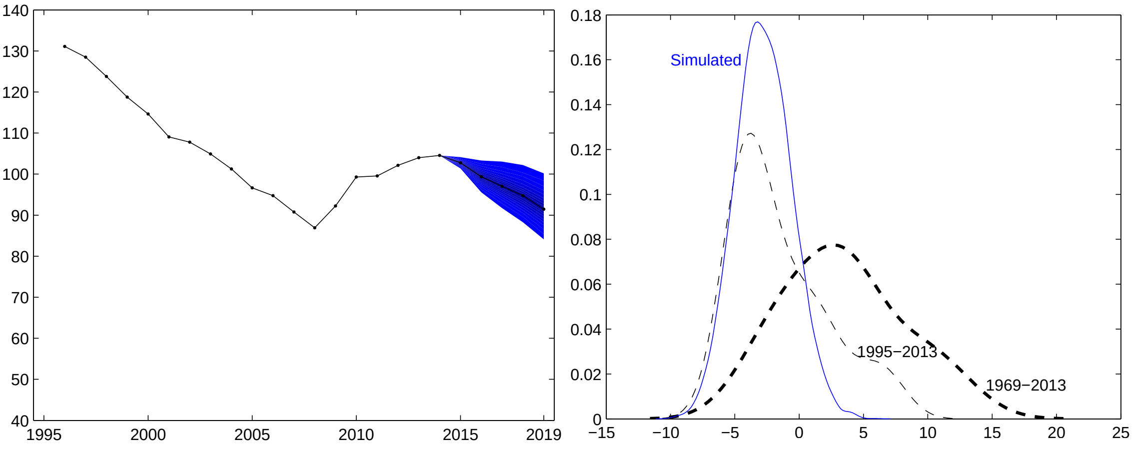
[23] It does require the assumption that the strength of fiscal rules remains constant. Simulations in general, however, rely on the assumption that future policy is sufficiently characterized by past behavior.



(a) Germany **(b) France**

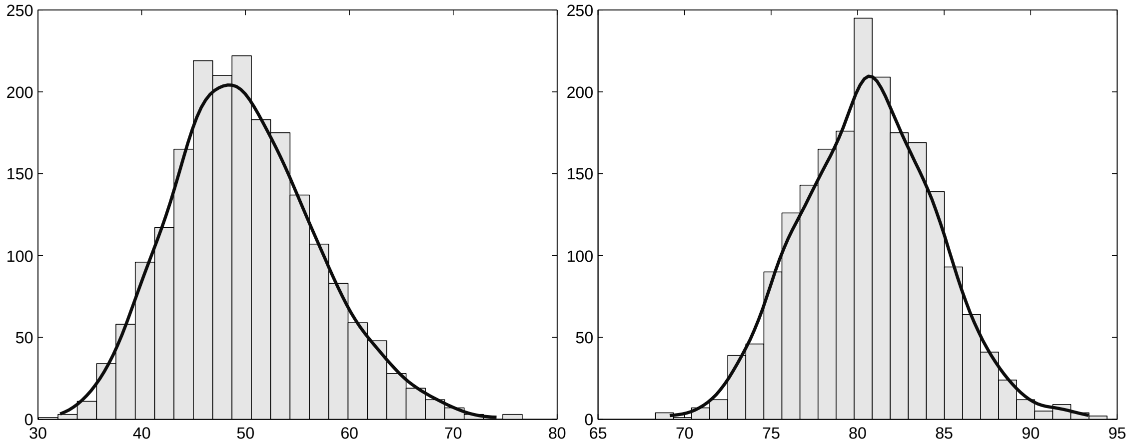


(c) Italy **(d) Spain**

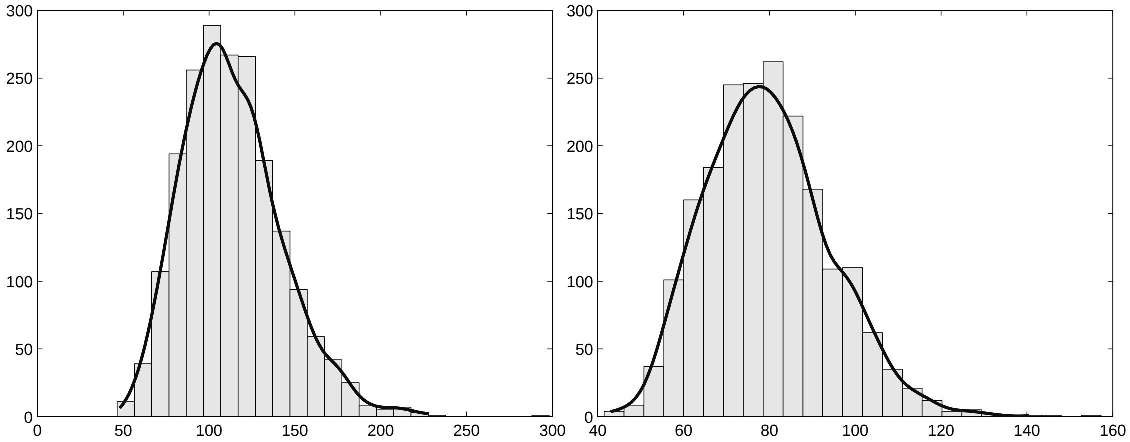


(e) Belgium **(f) Belgium:** Historic change in debt rate

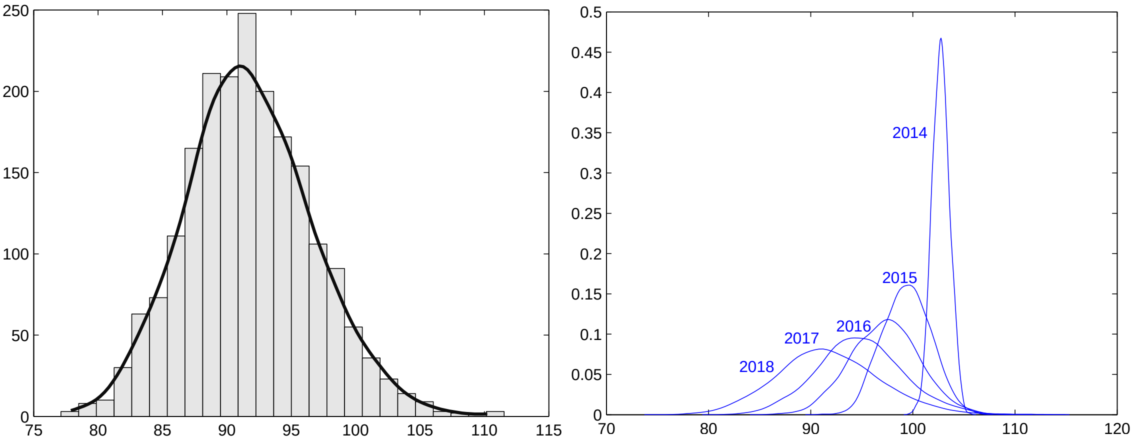
Figure 2: Yearly stochastic simulations of the public debt stock as a percentage of GDP for 2014-2018. Shaded areas portray the deciles of the projections, with different colors delineating different deciles. The deciles are based on 2.000 period-by-period Monte Carlo simulations of the estimated model. Panel (f) compares the changes in debt rate found compared to their historical values.



(a) Germany **(b) France**



(c) Italy **(d) Spain**



(e) Belgium **(f) Belgium:** Shift of the debt rate's kernel

Figure 3: Stochastic simulations of the public debt stock as a percentage of GDP at the end of 2018. Each histogram plots the number of occurrences of a certain debt rate based on 2.000 period-by-period Monte Carlo simulations of the estimated model. The full line portrays the fitted kernel. Panel (f) illustrates the movement of the distribution over the period of 2014-2018 for the case of Belgium.

4.1 Value-at-Risk Measures

There are no certain forecasts. Hence, we are interested in the probabilities of future realizations. Obviously, the distribution of debt stocks can be used to make inferences about the likelihood of certain future scenarios. For example, what is the ceteris paribus probability that the debt level in a certain EMU member state will (still) exceed 100 per cent of GDP in 2018? As illustrated by figure 2 and detailed further in table 20, this probability is highest for Italy.

Other interesting indicators can be constructed using the stochastic simulations as well. For instance, van Ewijk et al. (2013) construct an 'at risk' indicator, which is the difference between (a) the debt level in ten years that is higher than 97.5 per cent of all simulated debt levels and (b) the median debt level in ten years. Therefore, their measure indicates the likely deviation of the upward dispersion in the debt simulation. A similar measure can be computed for a 5 year horizon using the model in this paper. In line with the results of the variance decomposition, France (7.7), Belgium (11.1) and Germany (15.7) show a much smaller probability of upward risk than Spain (30.8) and Italy (67.3). In the case of bootstrapped shocks the degree of risk increases for all countries but Italy: France (12.2), Belgium (17.1), Germany (22.1), Italy (39.7) and Spain (45.5).

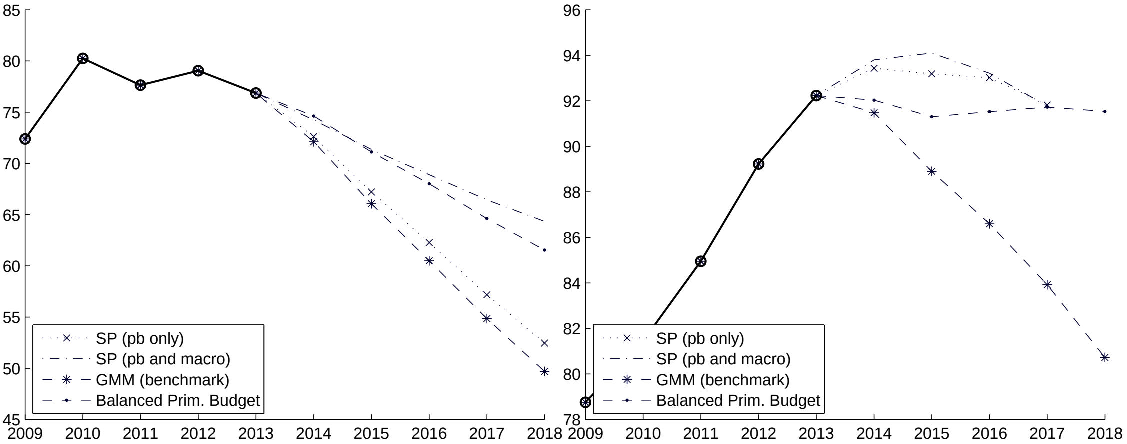
Nonetheless, apart from the direction of medium-term debt rates, these indicators do not constitute a strategy to ultimately satisfy the IBC. In order to substantiate disciplinary measures, more specific policy recommendations with respect to medium-term objectives (such as the MTOs in the preventative arm of the European Commission's fiscal policy oversight), however, seem to be a logical step forward. Especially given the pressing need to commit to solvent fiscal policies and the predominance of fiscal rules, this can be seen as the appropriate instrument to reach this goal.

4.2 Fiscal Rule Infringement Risks

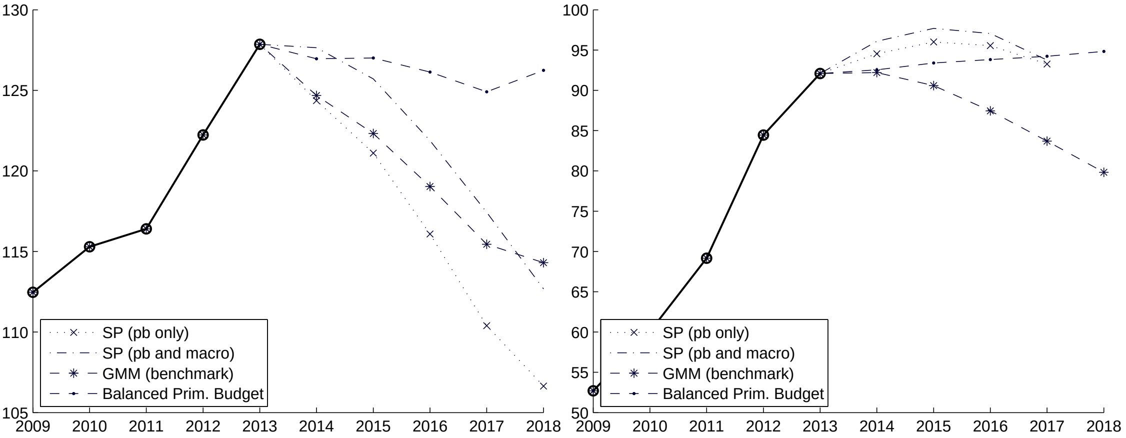
As an interesting point of comparison, the mean of the benchmark model is plotted against the projections by the respective national administrations or institutes, as included in the Stability Programmes (SP), in figure 4. Specifically, a scenario with the macro simulations from section 3.2 and the fiscal goals from the Stability Programmes is computed. Additionally, the complete SP-scenarios, including the underlying macro forecasts from the national administrations, is plotted. Interestingly, the differences between both scenarios are limited, indicating that the macro projections from section 3.2 differ little from those used by national administrations. Furthermore, it is striking to see how close the model's expected German, Italian and Belgian paths are to those set out in these member states' Stability Programmes, especially in the short-run. Hence, the programme goals set by these countries seem to follow historical fiscal behavior.

French and Spanish goals, nonetheless, provide more fiscal leeway in the short-run. Only after two to three years do they return to a slope in accordance to that found in historical fiscal reactions. The case for a yearly balanced primary budget is shown as an additional point of reference. The implications of uncertainty for the scenarios discussed above is presented next.

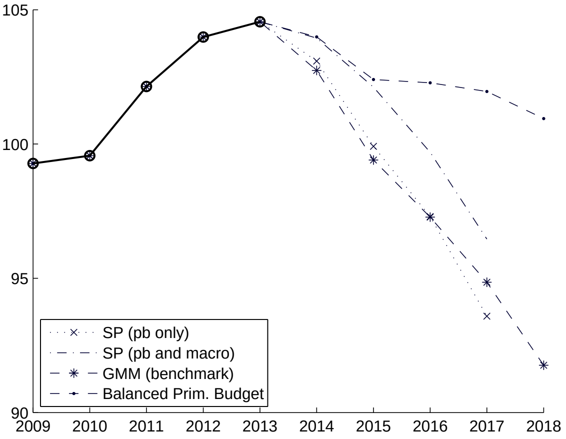
Figure 5 illustrates the probability distribution of the discrepancy between the simulated debt stock as a percentage of GDP and the one intended by each country based on its Stability Programme. In other words, it portrays the cumulative adjustment required to adhere to the Stability Programmes' debt targets. The additionally required, yearly adjustments to the primary balance as a percentage of GDP are shown in figure 6. In particular, the cases of infringement and, thus, the need for additional efforts are indicated in red. The first panel of table 10 summarizes the charts into a yearly risk measure by summing the probabilities of the breaches, i.e. the red bars. The results seem to be in favor of France and Spain. Nevertheless, the caveat is that, that their programmes are less ambitious. Not surprisingly, their goals are thus found to be achievable with more certainty.



(a) Germany **(b) France**

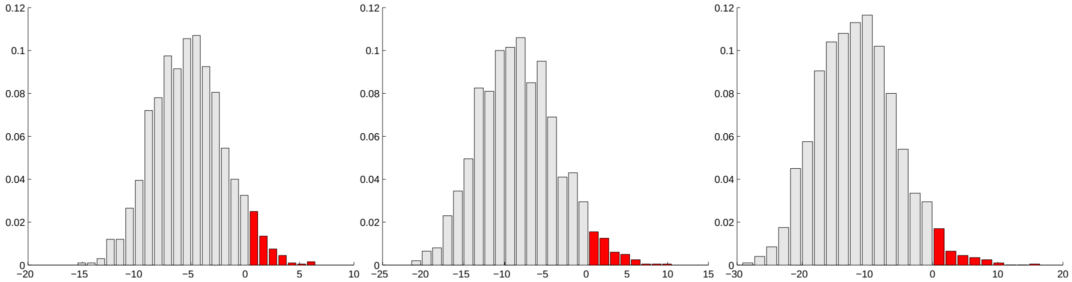


(c) Italy **(d) Spain**

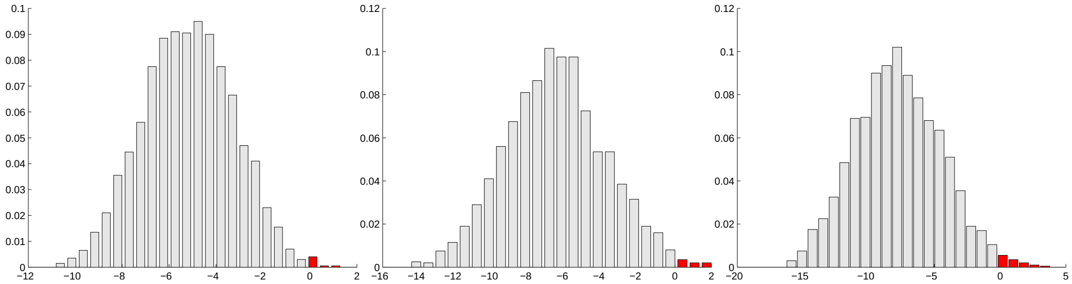


(e) Belgium

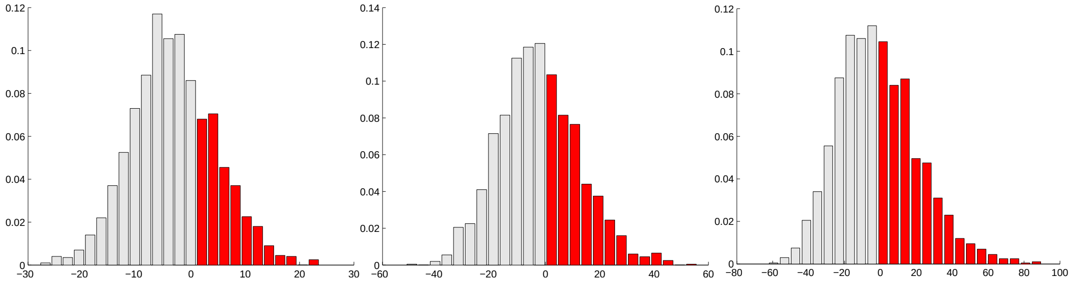
Figure 4: A comparison of the expected paths of the public debt stock as a percentage of GDP based on (i) the benchmark model's stochastic simulations; (ii) the Stability Programmes' fiscal targets in combination with own macro forecasts; (iii) the Stability Programmes' fiscal targets and the underlying macro projections; and (iv) a balanced primary budget.



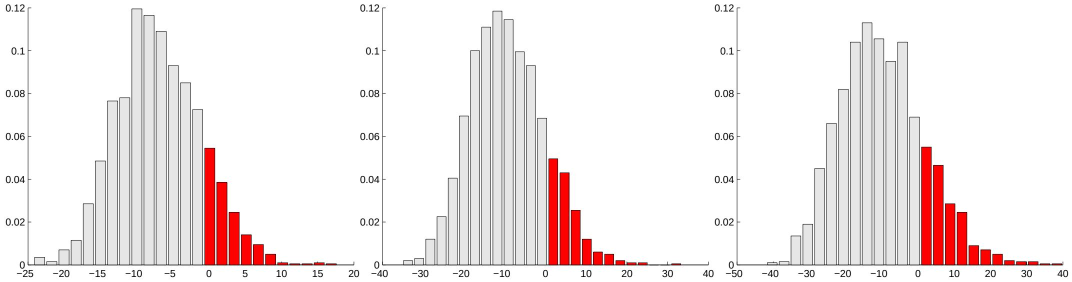
(a) Germany: 2015 **(b) Germany:** 2016 **(c) Germany:** 2017



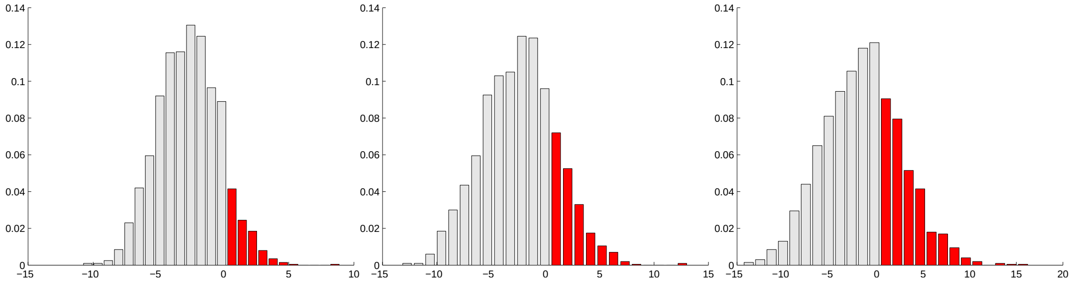
(d) France: 2015 **(e) France:** 2016 **(f) France:** 2017



(g) Italy: 2015 **(h) Italy:** 2016 **(i) Italy:** 2017

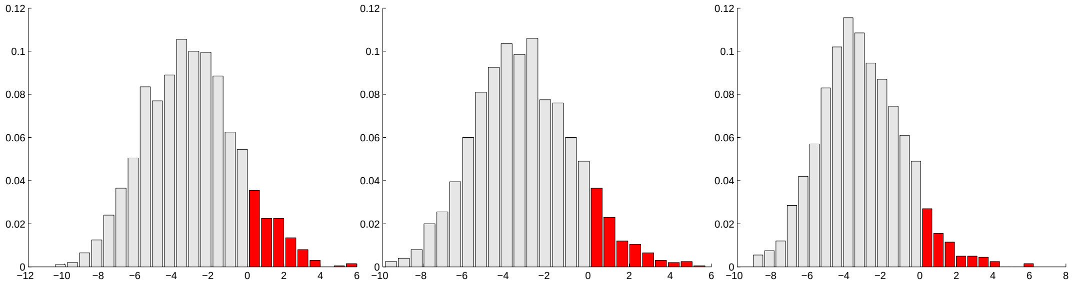


(j) Spain: 2015 **(k) Spain:** 2016 **(l) Spain:** 2017

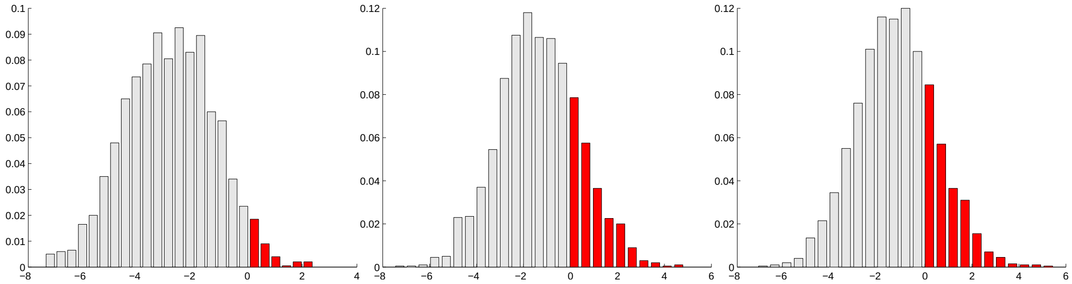


(m) Belgium: 2015 **(n) Belgium:** 2016 **(o) Belgium:** 2017

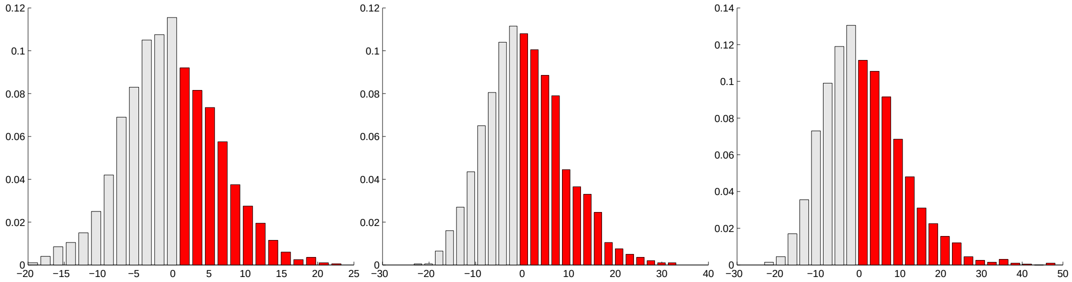
Figure 5: The probability distribution of the difference between the simulated and the intended debt stock as a percentage of GDP, i.e. the cumulative adjustment required to adhere to the Stability Programmes' debt targets. Excesses are indicated in red. The results are based on 2000 simulated shocks to the benchmark model.



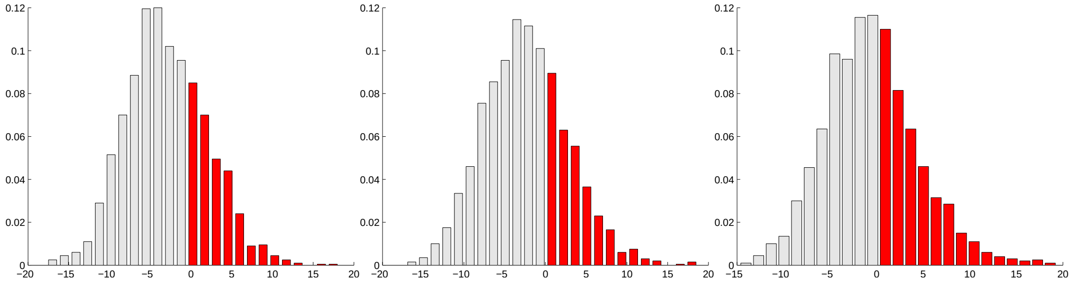
(a) Germany: 2015 **(b) Germany:** 2016 **(c) Germany:** 2017



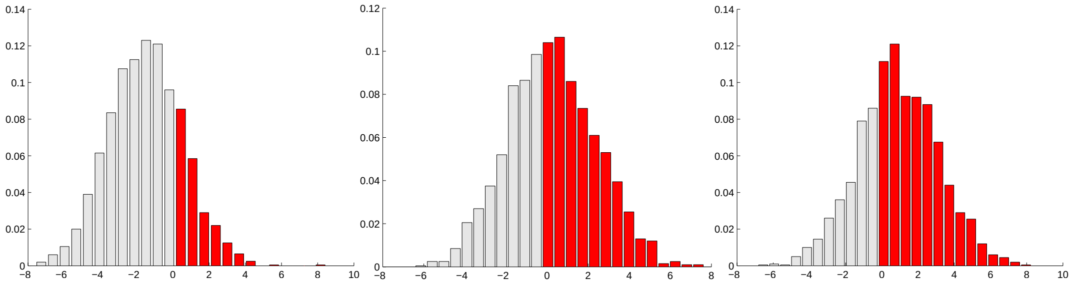
(d) France: 2015 **(e) France:** 2016 **(f) France:** 2017



(g) Italy: 2015 **(h) Italy:** 2016 **(i) Italy:** 2017



(j) Spain: 2015 **(k) Spain:** 2016 **(l) Spain:** 2017



(m) Belgium: 2015 **(n) Belgium:** 2016 **(o) Belgium:** 2017

Figure 6: The probability distribution of the additionally required, yearly adjustments to the primary balance as a percentage of GDP that are required in order to adhere to the targets set in the Stability Programmes. Cases in need of corrective action are indicated in red. The results are based on 2000 simulated shocks to the benchmark model.

Moreover, the case for Germany and - to a lesser extent - Belgium show that even in the case of strict targets, much uncertainty remains. Importantly, this uncertainty is not necessarily the result of primary budget blunders. In fact, ceteris paribus and under the assumption that historical fiscal reaction is a good proxy for governmental behavior, Germany for instance is expected to obtain its primary balance goals with certainty. Generally, the impact of shocks on the estimated primary balance remains limited, although great uncertainty remains for its debt rate, which could possibly require further adjustment. Therefore, the effect of interest rates and the impact of output in the denominator prove to be decisive.

Table 10: Countries' Infringement Risks

	i. Infringement of the Stability Programme				
	Germany	*France*	*Italy*	*Spain*	*Belgium*
2015	6.6%	0.4%	32.3%	12.8%	12.3%
2016	4.9%	0.8%	40.7%	15.6%	23.3%
2017	3.7%	1.2%	44.2%	19.5%	34.5%
2018	2.8%	*n.a.*	63.8%	*n.a.*	*n.a.*
	ii. Infringement of the Debt Brake				
	Germany	*France*	*Italy*	*Spain*	*Belgium*
2015	0.2%	98.7%	90.1%	97.1%	80.3%
2016	0.4%	38.7%	52.6%	49.1%	43.4%
2017	0.9%	19.4%	48.2%	36.7%	35.6%
2018	0.7%	11.0%	48.0%	26.5%	33.1%
	iii. Infringement of MTO Adjustment Path				
	Germany	*France*	*Italy*	*Spain*	*Belgium*
2015	1.2%	0.2%	11.8%	0.2%	0.5%
2016	21.7%	4.4%	18.4%	9.5%	2.9%
2017	67.4%	25.9%	44.2%	27.8%	29.8%
2018	87.0%	48.4%	52.1%	49.1%	55.3%

Notes: The risks convey the probabilities that member states do not reach (i) the debt level resulting from the targets set in their Stability Programmes; (ii) the debt rate that follows the debt brake; and (iii) a sufficiently large cyclically adjusted budget balance (CABB) to allow them to move towards their MTO at a sufficient pace. Results are based on 2000 simulated shocks to the benchmark model as described above.

To prevent ending up in the EDP, countries with a debt rate exceeding 60% of GDP must moreover reduce this difference by a minimum of 5 pp. per year over a period of three years.[24] The probability for the examined member states to achieve the debt levels set out by this debt brake rule are included in table 10 as well. In contrast to the first infringement measure, this measure does account for the ambitiousness of the targets set by countries. For example, Germany now clearly

---

[24] For example, if the debt-to-GDP ratio is 80% in the year preceding the last year, then for the period covering the last year and the subsequent two years it should decline with at least: 0.05 * 20% = 1.0 percentage point per year, resulting in a limit of 77.0% three years later.

does better in comparison to France and Spain. Still, due to the importance of the initial distance from the debt target, countries with a lower initial debt level are less burdened to take action. Therefore, they will achieve their objectives more easily. While Germany thus has little chance of flouting the debt brake, great uncertainty remains for countries already under strict supervision (e.g. Belgium).

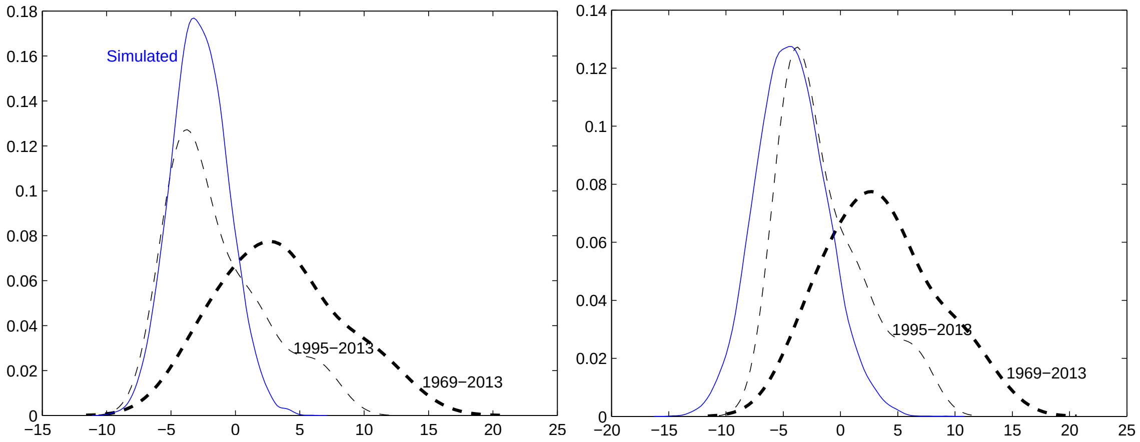
Finally, all Member States must reach their MTOs or be on an appropriate adjustment path towards them, with an annual improvement in their structural balance of 0.5% of GDP. The third panel of table 10 shows the corresponding infringement risk measure. Not surprisingly, the likelihood that a country does not achieve the required adjustment of its Cyclically Adjusted Budget Balance (CABB) increases as the horizon period lengthens. Noteworthy, however, is the high short-run uncertainty in Italian fiscal policy for meeting its goals. Consequently, this higher intrinsic uncertainty of Italian fiscal policy may impel policy makers to enforce stricter surveillance in order to hedge against disadvantageous outcomes.

4.3 Policy Uncertainty

Panel (f) of figure 3 included an illustrative comparison of the simulated changes in the Belgian debt rate with its historical counterparts. It is noticeably more optimistic than those observed over the full history of the series (1969-2013). Nonetheless, the kernel of the simulated changes in the debt rate comes close to that of the evolutions since 1995.

The remaining differences can be explained by either (i) possible discrepancies between the macroeconomic shocks simulated and those that occurred in practice or (ii) the uncertainty concerning fiscal policy decisions not included so far. As shown in section 5, a comparison of the benchmark model to that with bootstrapped macro shocks shows that the first option may be excluded as the primary reason. Policy makers may, however, deviate from historical fiscal reactions for multiple reasons, thereby accounting for the slight bias observed in the simulations.

So far, deviations by policy makers from their historical behavior were left out of the picture in the analysis. Nonetheless, the panel estimations from section 3.3 provide data on the deviations



(a) Belgium: Without policy uncertainty **(b) Belgium:** Including policy uncertainty

Figure 7: A comparison of the simulated changes in the debt rate for the period of 2014-2018 to their historical values. The kernels of the simulated changes are based on 2.000 period-by-period Monte Carlo simulations of the estimated model.

observed in the past, i.e. the residuals. Adding an uncertainty component to the fiscal component of the model has not been seen in earlier research, but adds to its insightfulness.

Specifically, in what follows I extend each period's fiscal reaction with a random draw from a normal distribution having the mean and standard deviation of the country's residuals. This improves the robustness of the results. For example, as illustrated in figure 7, the simulated changes in the Belgian debt rate are more in line with those observed during recent decades.

Adding an additional source of uncertainty to the model straightforwardly results in a widening of the fan charts of the evolution of the simulated debt stock as a percentage of GDP (see figure 8). The impact of this effect can be clearly observed from the VaR-measures for upward risk, which are higher for all countries. France (15.2), Belgium (21.3) and Germany (28.1) still show a smaller probability of upward risk than Spain (47.5) and Italy (73.1). Yet, the increase in upward risk (expressed in terms of debt in 2018 as a percentage of GDP) is smallest for Italy: 5.8 in comparison to 7.5 for France, 10.2 for Belgium, 12.4 for Germany and 16.7 for Spain.

Although the range of possible outcomes increases, the infringement risks as introduced in subsection 4.2 do not necessarily change. After all, the upward risk only points to the undesirable, but possible scenarios, without taking into account their likelihood. As long as the weight on such scenarios within the distribution of all simulations turns out to be sufficiently small, the likelihood

Table 11: Countries' Infringement Risks, incl. Policy Uncertainty

i. Infringement of the Stability Programme

	Germany		*France*		*Italy*		*Spain*		*Belgium*	
2015	7.6%	+1.0	5.3%	+4.9	23.4%	-8.9	24.4%	+11.6	6.3%	-6.0
2016	5.2%	+0.3	7.6%	+6.8	30.8%	-9.9	27.7%	+12.1	9.4%	-13.9
2017	3.8%	+0.1	9.3%	+8.1	34.3%	-9.9	34.1%	+14.6	10.4%	-24.1
2018	2.7%	-0.1	*n.a.*		38.6%	-25.2	*n.a.*		*n.a.*	

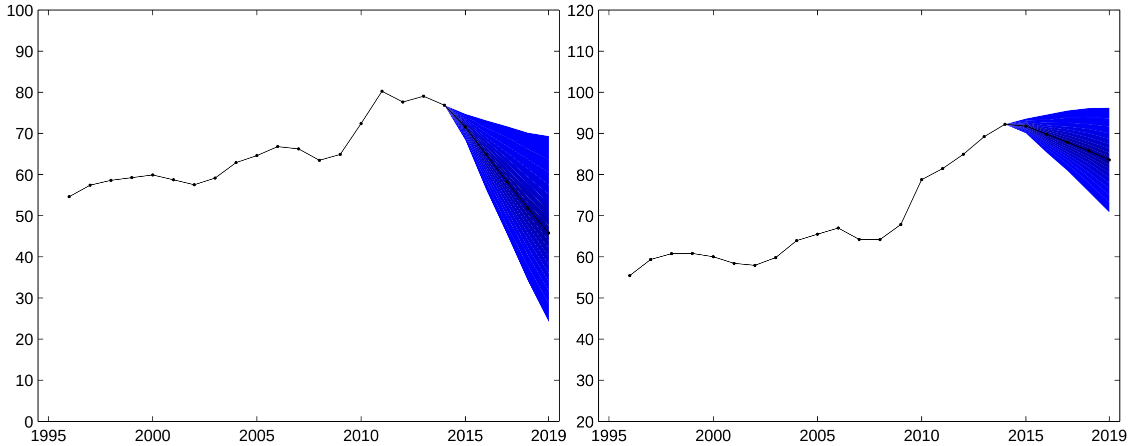
ii. Infringement of the Debt Brake

	Germany		*France*		*Italy*		*Spain*		*Belgium*	
2015	0.6%	+0.4	98.0%	-0.7	81.6%	-8.5	96.1%	-1.0	49.5%	-30.8
2016	1.0%	+0.6	60.3%	+21.6	41.8%	-10.8	61.8%	+12.7	17.5%	-25.9
2017	0.8%	-0.1	41.7%	+22.3	40.2%	-8.0	50.4%	+13.7	11.4%	-24.2
2018	0.9%	+0.2	32.6%	+21.6	39.5%	-8.5	43.3%	+16.8	8.5%	-24.6

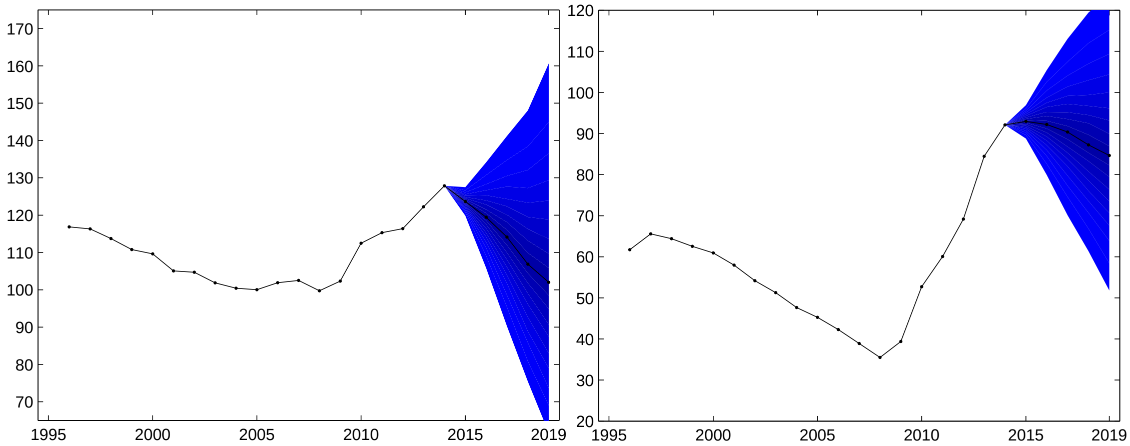
iii. Infringement of MTO Adjustment Path

	Germany		*France*		*Italy*		*Spain*		*Belgium*	
2015	32.0%	+30.8	1.7%	+1.5	12.7%	+0.9	10.1%	+9.9	6.8%	+6.3
2016	47.0%	+25.3	13.7%	+9.3	21.4%	+2.0	26.2%	+16.7	16.7%	+13.8
2017	61.6%	-5.8	32.6%	+6.7	45.5%	+1.3	37.6%	+9.8	41.0%	+11.2
2018	66.1%	-20.9	47.9%	-0.5	54.2%	+1.9	47.1%	+2.0	60.5%	+5.2

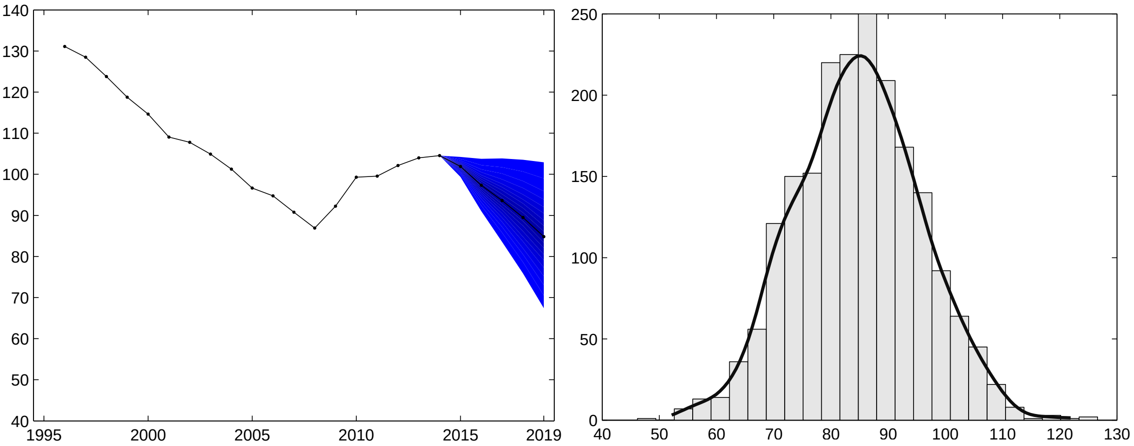
Notes: The risks convey the probabilities that member states do not reach (i) the debt level resulting from the targets set in their Stability Programmes; (ii) the debt rate that follows the debt brake; and (iii) a sufficiently large cyclically adjusted budget balance (CABB) required for them to move towards their MTO at a sufficient pace. Results are based on 2000 simulated shocks to the benchmark model as described above. The changes as a result of the inclusion of policy uncertainty in the model are given next to each figure.



(a) Germany **(b) France**



(c) Italy **(d) Spain**



(e) Belgium **(f) Belgium:** Historic change in debt rate

Figure 8: Yearly stochastic simulations of the public debt stock as a percentage of GDP for 2014-2018, *including policy uncertainty*. Shaded areas portray the deciles of the projections, with different colors delineating different deciles. The deciles are based on 2.000 period-by-period Monte Carlo simulations of the estimated model. Panel (f) plots the number of occurrences of a certain debt rate for Belgium at the end of 2018.

of a breach does not necessarily have to increase. In fact, this is what we see in table 11, where both the infringement risks with fiscal policy uncertainty in the model as well as the change with respect to table 10 are shown.

4.4 Decomposition of the Variance of Public Debt

To illustrate the influence of the different sources of uncertainty I decompose the variance of the simulations' debt rates. In particular, table 12 shows the decomposition for Belgium. An overview for all five countries is appended in table 21. The first three columns are simulated under the assumption that only the corresponding column of the respective macro variable remains non-zero in the factorized variance-covariance matrix. In the following columns the number of non-zero columns is increased in a stepwise fashion. The seventh column represents the standard deviation of the debt rate found under the full variance-covariance as portrayed by the results in figures 2 and 3. Finally, the policy uncertainty is added to the fiscal reaction.

As was already clear from the figures, the uncertainty increases the further ahead that predictions are made. More striking, however, are the differences between countries. For instance, Italian debt is characterized by a considerably larger uncertainty than its European counterparts. Percentage-wise German and Spanish debt are also not without uncertainty. Belgian and French debt projections, on the other hand, show relatively little uncertainty. The influence of policy uncertainty is limited relative to that of the shocks in macroeconomic drivers. Nonetheless, it is not without importance, especially for Germany and Spain.

Several causes of the cross-country differences in uncertainty are conceivable. First, both a country's automatic stabilizers and discretionary policy may differ. Nonetheless, except for possible country fixed effects, the estimated reaction functions do not allow for respective differences in uncertainty. Second, the VAR-model may not be able to estimate the actual data as reliable for each member state. However, the limited differences in root mean squared errors (cf. table 16) do not align with the discrepancies in uncertainty from the variance decompositions. Therefore, differences are mainly to be attributed to historically larger variances in the macro variables of some countries compared to others. Overall, the uncertainty is mainly the result of output shocks, although considerable long-term effects of interest uncertainty also exist.

Table 12: Decomposition of the Public Debt's Variance

	Macroeconomic Uncertainty							*Policy Uncert.*	*Total Uncert.*
	Individual Effects			*Correlation*			*Full*		
	g_t	π_t	r_t	$\{g_t, \pi_t\}$	$\{g_t, r_t\}$	$\{\pi_t, r_t\}$	$\{g_t, \pi_t, r_t\}$		
2014	0.49	0.50	0.48	0.69	0.69	0.65	0.83	0.66	1.49
2015	2.11	0.88	0.60	2.32	2.20	1.06	2.37	0.82	3.19
2016	3.24	0.94	0.82	3.34	3.32	1.20	3.41	0.97	4.38
2017	3.84	1.33	1.27	4.01	4.04	1.79	4.22	1.17	5.39
2018	4.40	1.91	1.60	4.70	4.53	2.40	4.95	1.46	6.41

Notes: Figures denote standard deviations of the Belgian debt rate d_t. The first three columns are simulated under the assumption that only the corresponding column of the respective macro variable remains non-zero in the factorized variance-covariance matrix. In the following columns the number of non-zero columns is increased stepwise. The seventh column represents the standard deviation of the debt rate found under the full variance-covariance specified by equations (4) and (5). Finally, policy uncertainty is added to the reaction function.

5 Robustness Checks

5.1 Bootstrap

As a point of comparison shocks are bootstrapped in block - i.e. a vector for the three shocks is drawn simultaneously - such that the generated kernel of the shocks approaches their historical distribution. In particular, 10.000 vectors of shocks to the macro variables are drawn with replacement from the historic residuals of the VAR models. As a means of illustration, the kernels of the bootstrapped innovations of each macro variable are separately compared to the kernels from the original, normally distributed model in figure 9.

Overall, the benchmark model performs relatively well. In fact, it does an outstanding job for Germany. Nonetheless, the economic growth is underestimated in the case of Italy. As a result, the end-of-year debt rate in 2018 is considerably less in the bootstrapped alternative (see figure 10). For the three other countries, the benchmark model has trouble capturing the distribution of shocks in interest rates. Furthermore, the normal probability plots for each country-variable pair are included in figure 13 in the appendix. They clearly illustrate that within reasonable bounds the shocks are normal, but that the tails are not. In other words, the benchmark model is not suitable to make inferences about extremities as it underestimates the probability of large upward and downward shocks in favor of medium sized shocks.

5.2 Alternative Paths

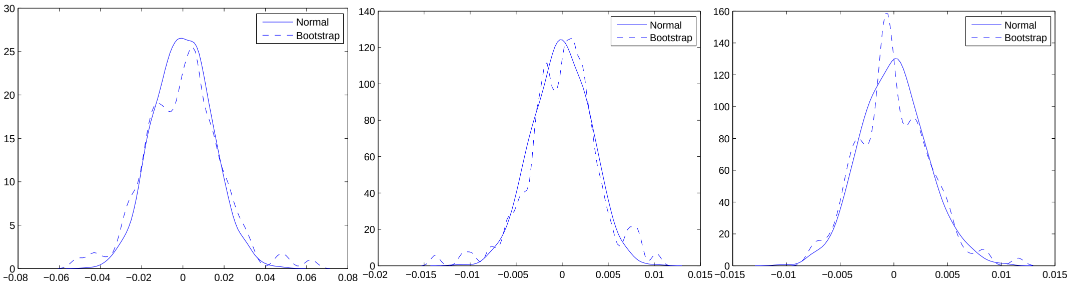
As an alternative to using model (12) from table 4, other models could be used. To illustrate the importance of the differences in the estimated coefficients of the reaction functions, I compare several different specifications of the fiscal determinants.

Next to the benchmark dynamic GMM-model from table 4, the following alternative estimation models considered are: (i) the dynamic LSDVC-model for the core countries (model (4) from table 4); (ii) a combination of the dynamic LSDVC-models for the expenditures and revenues of the core countries (models (9) from tables 6 and 7); and (iii) a re-estimation of the dynamic LSDVC-model for the core countries using output growth instead of the output gap.

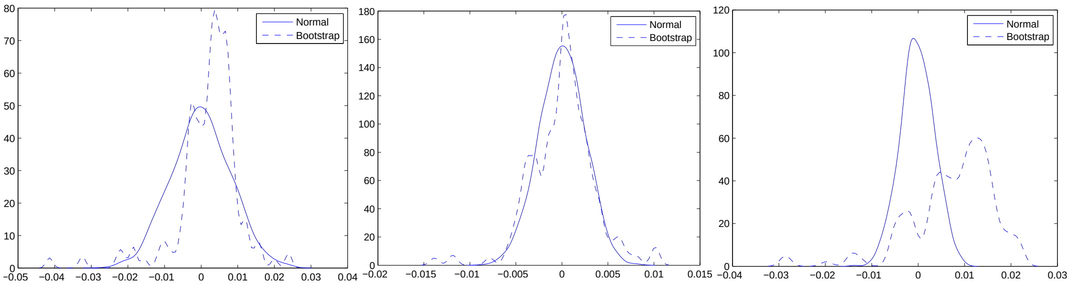
As illustrated by figure 11 the main difference between the different estimation models' paths is to be found by switching from the output gap to output growth as an explanatory variable. In all cases, doing so worsens expectations about the future path of the public debt stock as a percentage of GDP. Furthermore, it is to be noted that, in contrast to the benchmark shocks, the use of bootstrapped shocks may further deteriorate prospects. The German projections seem the most robust, since the bootstrapped paths only differ by a negligible amount. This is in line with the expectations based on figure 9. For the other countries, however, this does not appear to be the case. In panel (f) of figure 11 I illustrate the case for Belgium. Italian prospects, as an exception, brighten as a result of more favorable bootstrapped growth shocks.

6 Concluding Remarks

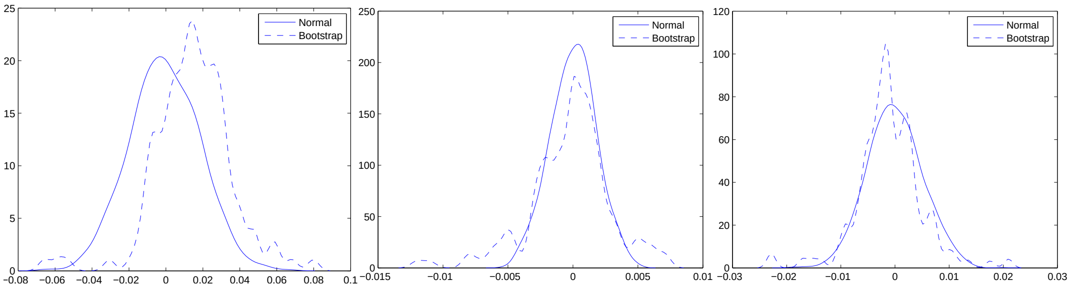
The significance of disentangling how fiscal policy uncertainty shapes economic outcomes is now universally accepted. Consequently, there is a need for forward looking policy instruments taking into account the uncertainty as well as the institutional and macro-financial factors underlying them. Nonetheless, the respective literature has mainly focused on the reaction coefficient of the primary balance as regards the debt-to-GDP ratio and has ignored the direct implications for the fiscal disciplinary rules imposed in practice. This paper therefore builds upon the existing methodology and comes to enhanced stochastic projections of EMU member states' public finances.



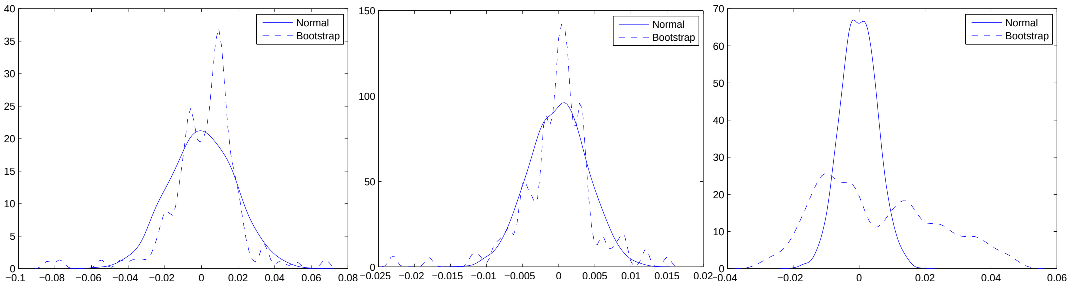
(a) Germany: real GDP **(b) Germany:** inflation **(c) Germany:** interest rate



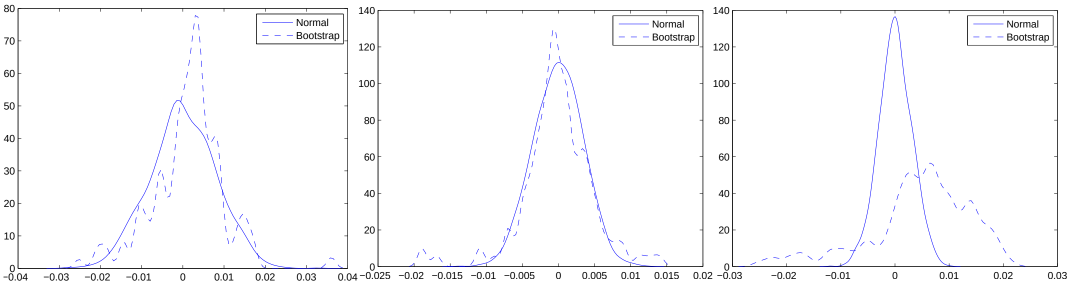
(d) France: real GDP **(e) France:** inflation **(f) France:** interest rate



(g) Italy: real GDP **(h) Italy:** inflation **(i) Italy:** interest rate

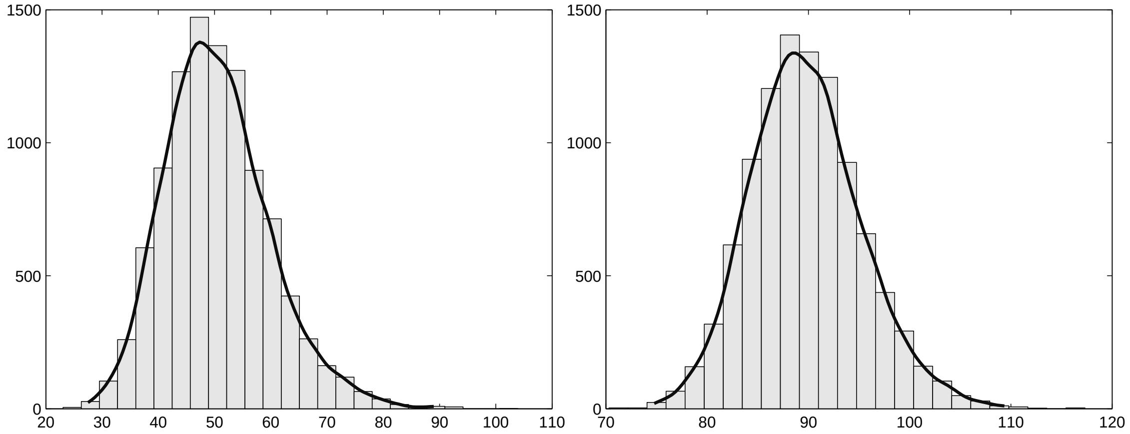


(j) Spain: real GDP **(k) Spain:** inflation **(l) Spain:** interest rate

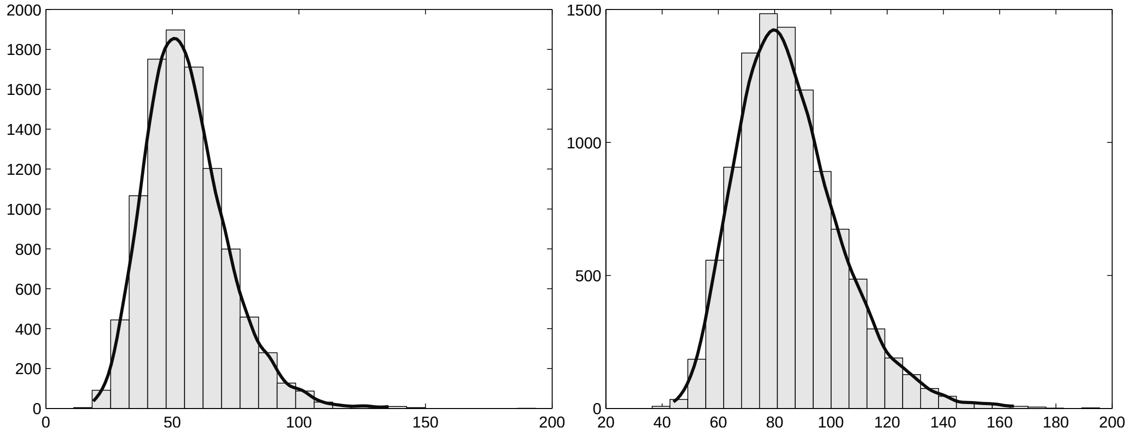


(m) Belgium: real GDP **(n) Belgium:** inflation **(o) Belgium:** interest rate

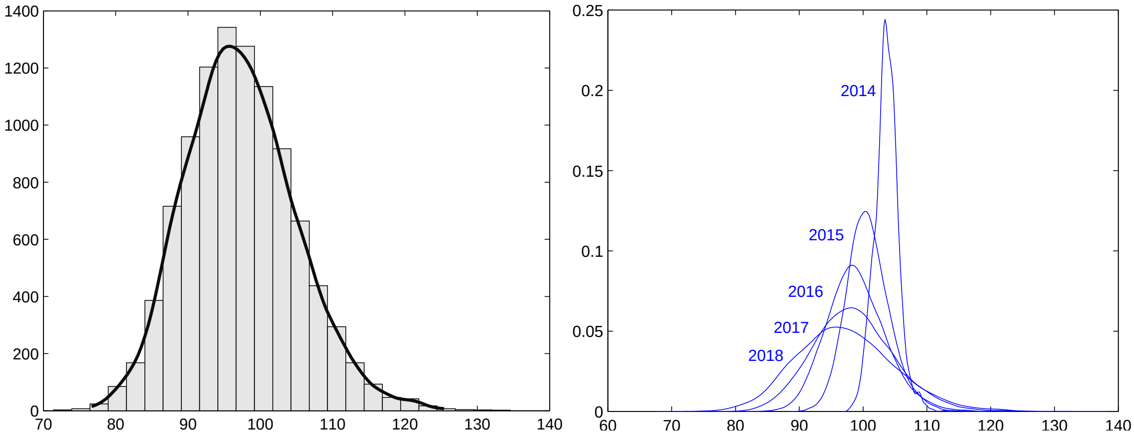
Figure 9: Comparison of the kernels of the innovations to X_t (at the end of 2018) based on (a) 2.000 period-by-period Monte Carlo simulations of the estimated models from their estimated covariance matrix, $\hat{\Omega}$; and on (b) 10.000 block bootstrapped innovations from the estimated models' historic residuals.



(a) Germany **(b) France**

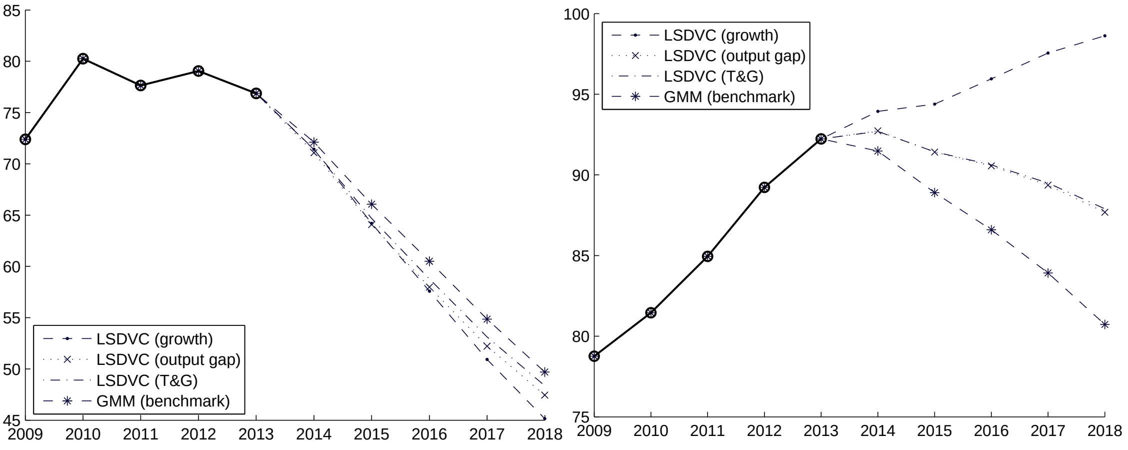


(c) Italy **(d) Spain**

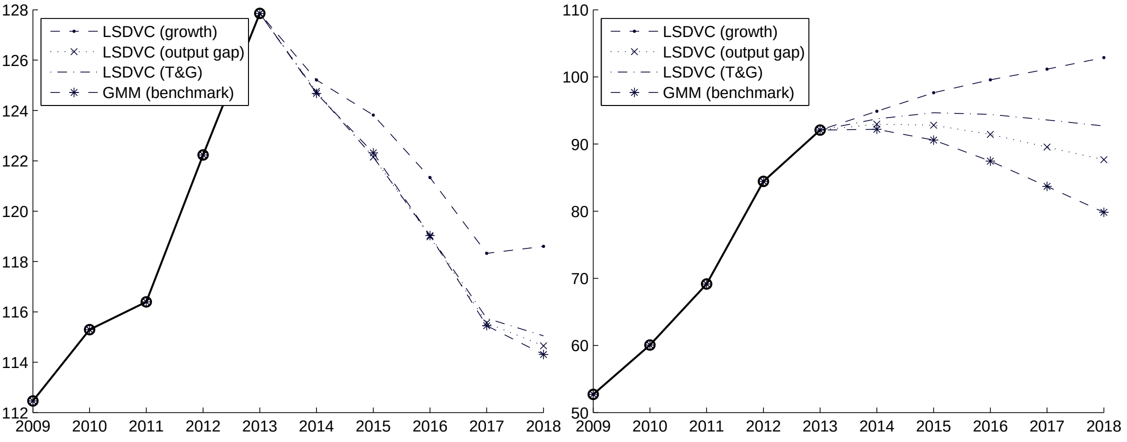


(e) Belgium **(f) Belgium:** Shift of the debt rate's kernel

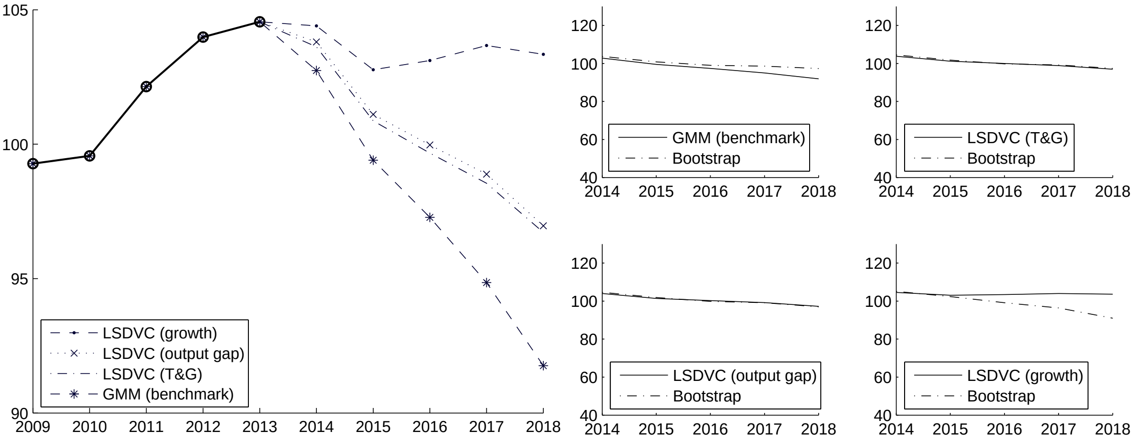
Figure 10: Bootstrapped stochastic simulations of the public debt stock as a percentage of GDP at the end of 2018. Each histogram plots the number of occurrences of a certain debt rate based on 10.000 period-by-period Monte Carlo simulations of the estimated model using block bootstrapped innovations. The full line portrays the fitted kernel. Panel (f) illustrates the movement of the distribution over the period of 2014-2018 for the case of Belgium.



(a) Germany **(b) France**



(c) Italy **(d) Spain**



(e) Belgium **(f) Belgium:** benchmark vs. bootstrapped

Figure 11: Panels (a) to (e) show a comparison of the expected paths of the public debt stock as a percentage of GDP based on the different fiscal reaction functions' stochastic simulations. Panel (f) contains a comparison of the benchmark estimated projections for Belgium to its respective alternative with bootstrapped shocks.

The estimation of fiscal determinants shows that the responsiveness of the primary balance to economic fluctuations is generally found to be larger in the core European countries. Discretionary policy, in its turn, is found to be procyclical on average, especially in peripheral countries. The long-term interest rate is not found to be significant and the evidence of fiscal drag through bracket creep is ambiguous. Including a measure of the institutional guarantees for fiscal discipline, on the other hand, does seem to have a favorable impact on a country's primary balance. In particular, incorporating the fiscal rule index into the model results in findings that are in accordance with earlier findings that suggest the effectiveness of stronger fiscal rules. Fiscal policy adjustments, however, differ significantly for public revenues and primary expenditures.

Additionally, the paper employs time series analysis to characterize the joint dynamics of the uncertainty existing for economic growth, inflation and interest rates. This, in combination with the estimation of fiscal determinants, allows for the application of a Monte Carlo-based approach to derive the distribution of expected fiscal realizations. The benchmark model is found to perform well. For example, the overall macro projections resulting from the vector autoregression differ little from those used by national administrations in drawing up their Stability Programmes.

As the result of historically larger variances in its macro drivers, Italian debt is found to be characterized by a considerably larger uncertainty than its European counterparts. German and Spanish debt are also not without uncertainty. Spain, for example, is the most likely not to live up to the debt brake in the medium-run. However, using bootstrapped shocks deteriorates prospects for all countries but Germany. Furthermore, Germany, France and Belgium show a much smaller upward risk than Spain and Italy.

Interestingly, the targets set out in German, Italian and Belgian Stability Programmes are very close to the model's expected budgetary paths, especially in the short-run. Hence, the programme goals set by these countries seem to follow historical fiscal behavior. French and Spanish goals, nonetheless, provide relatively more fiscal leeway in the short-run. In all cases, the choice to include economic growth instead of the output gap in the fiscal reaction function worsens expectations about the future path of the debt rate.

Finally, three risk measures that quantify the likelihood of fiscal rule infringements are set forth. A first measure captures the distribution of the possibly required adjustments of fiscal policy for adhering to the Stability Programmes' targets. It seems to favor the French and Spanish prospects. The caveat is that this result is driven by their programmes being relatively less ambitious. The second indicator, quantifying the probability that the member states achieve the debt levels set out by the European debt brake rule, does account for the ambitiousness of the targets. Consequently, while Germany is found to have little chance of flouting the debt brake, it points to great uncertainty for countries already under strict supervision (e.g. Belgium). Thirdly, the risk that a country does not achieve the required adjustment of its cyclically adjusted budget balance in order to be on the appropriate path towards its medium-term objective is analyzed. In particular, it shows that Italian fiscal policy portrays a disturbingly high short-run uncertainty in comparison to other member states. This higher intrinsic uncertainty is valid ground for impelling policy makers to enforce stricter surveillance to hedge against disadvantageous outcomes.

Appendix

Table 13: Data Descriptives of the Non-fiscal determinants

	Definition	*Country*	*Root*	*Mean*	*St.Dev.*	*Min.*	*Max.*
g_t	Real GDP growth rate[1]	DE	I(0)	0.0113	0.0181	-0.0394	0.0744
		FR	I(0)	0.0107	0.0100	-0.0270	0.0463
		IT	I(0)	0.0139	0.0220	-0.0657	0.0794
		ES	I(0)	0.0136	0.0204	-0.0633	0.0843
		BE	I(0)	0.0109	0.0105	-0.0261	0.0472
π_t	Consumer price index[2]	DE	I(1)	0.0164	0.0093	-0.0060	0.0420
		FR	I(1)	0.0205	0.0130	-0.0050	0.0590
		IT	I(1)	0.0257	0.0100	0.0010	0.0480
		ES	I(1)	0.0257	0.0094	-0.0100	0.0460
		BE	I(1)	0.0197	0.0109	-0.0120	0.0520
r_t	EMU convergence criterion bond yields[3]	DE	I(1)	0.0559	0.0221	0.0134	0.1056
		FR	I(0)	0.0700	0.0378	0.0186	0.1686
		IT	I(1)	0.0908	0.0504	0.0309	0.2121
		ES	I(0)	0.0878	0.0464	0.0292	0.1781
		BE	I(0)	0.0685	0.0321	0.0199	0.1381

[1] The series for France, Spain and Belgium obtained from the Eurostat Statistics Database were deseasonalized and corrected for the number of working days beforehand. For Germany and Italy the series obtained from Eurostat were already corrected for the number of working days, but still required manual deseasonalization.

[2] Data obtained from OECD.Stat, with original index set at 100 in 2010.

[3] Data obtained from the Eurostat Statistics Database.

Table 14: Data Descriptives of the Fiscal Determinants (as a % of GDP)[1]

	AT		*BE*		*DK*		*FI*		*FR*		*DE*		*IE*	
	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ
Total revenues	48.92	0.81	48.74	0.98	54.54	0.75	53.27	1.50	50.29	1.03	44.12	1.09	35.41	1.81
Income & wealth taxes	13.10	0.60	16.17	0.52	29.07	0.75	17.19	1.25	10.96	1.28	11.31	0.64	13.18	0.66
Production & import taxes	14.49	0.41	12.74	0.23	16.89	0.48	13.46	0.57	15.27	0.46	10.60	0.28	12.24	1.14
Employers' social contrib.	7.72	0.44	10.37	0.32	0.44	0.10	8.87	0.42	12.72	0.29	8.15	0.45	4.18	0.29
Households' social contrib.	7.61	0.13	5.41	0.14	1.17	0.28	3.41	0.43	5.39	0.71	9.33	0.51	1.23	0.15
Property income	1.28	0.12	0.94	0.18	2.17	0.39	3.48	0.44	0.83	0.16	0.79	0.12	0.93	0.41
Capital taxes	0.06	0.06	0.59	0.17	0.21	0.03	0.26	0.05	0.46	0.06	0.16	0.05	0.16	0.05
Other	4.66	0.70	2.52	0.35	4.58	0.39	6.59	0.80	4.67	0.20	3.78	0.28	3.48	0.49
Total expend.	51.00	1.61	50.35	2.18	54.06	2.79	51.98	4.11	54.16	1.55	45.65	1.84	37.09	4.52
Primary expend.	47.74	1.43	45.11	3.01	51.08	2.49	49.78	3.89	51.37	1.71	42.81	1.61	34.61	4.00
Social benefits & transfers	24.75	0.68	24.55	1.62	21.59	1.23	21.59	2.02	26.07	1.64	26.56	0.85	14.18	2.95
Employees' compensation	10.96	0.37	11.63	0.43	16.16	0.66	13.59	0.76	12.91	0.25	8.05	0.41	10.02	1.15
Intermediate consumption	5.88	0.50	3.76	0.21	8.17	0.90	9.04	1.37	4.93	0.23	3.96	0.39	5.22	0.33
Capital formation	2.95	0.41	2.17	0.15	2.98	0.31	3.81	0.27	3.98	0.16	2.21	0.20	3.30	0.91
Subsidies	1.87	0.36	1.96	0.63	2.07	0.15	1.49	0.34	1.52	0.15	1.33	0.35	1.03	0.12
Other	1.33	0.43	1.04	0.24	0.12	0.19	0.25	0.08	1.96	0.34	0.71	0.55	0.86	0.27
Interest burden	3.26	0.39	5.24	1.83	2.98	1.42	2.19	1.01	2.78	0.34	2.84	0.38	2.48	1.39
Primary balance	1.18	1.32	3.63	2.61	3.46	2.51	3.48	3.28	-1.08	1.46	1.31	1.48	0.80	4.84
Cycl. adj. prim. bal.[2]	0.59	1.14	3.12	2.46	3.01	1.29	3.28	2.35	-1.08	1.39	0.61	1.98	-1.05	7.69
Fiscal rule index[3]	0.07	0.62	0.24	0.21	1.26	0.46	0.67	0.29	0.30	0.64	0.65	0.32	-0.90	0.10

Table 14 (continued): Data Descriptives of the Fiscal Determinants (as a % of GDP)[1]

	IT		*LU*		*NL*		*PT*		*ES*		*SE*		*UK*	
	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ
Total revenues	45.03	1.30	43.08	1.07	43.39	1.04	40.46	1.81	38.44	1.32	54.23	2.41	38.55	1.26
Income & wealth taxes	13.99	0.70	14.55	0.89	10.86	0.54	8.86	0.75	10.16	0.80	19.36	1.21	14.90	0.75
Production & import taxes	13.81	1.01	12.76	0.52	11.33	0.44	13.78	0.54	10.86	0.95	22.51	0.70	12.40	0.48
Employers' social contrib.	8.99	0.55	10.09	0.59	4.70	0.88	7.49	0.62	9.21	0.21	3.68	0.70	4.45	0.30
Households' social contrib.	3.83	0.35	1.34	0.08	9.71	1.51	3.58	0.20	3.41	0.14	0.98	0.97	3.11	0.19
Property income	0.64	0.15	1.81	0.37	2.44	0.48	0.96	0.23	1.09	0.33	2.38	0.60	0.82	0.29
Capital taxes	0.33	0.34	0.12	0.04	0.28	0.04	0.06	0.06	0.41	0.06	0.05	0.05	0.29	0.34
Other	3.44	0.16	2.41	0.19	4.08	0.13	5.73	0.66	3.29	0.21	5.25	0.39	2.58	0.58
Total expend.	48.33	1.79	41.09	2.38	44.77	2.11	45.28	2.87	40.92	2.76	54.14	3.72	42.22	3.37
Primary expend.	42.28	2.10	40.74	2.36	41.97	2.25	41.83	2.93	38.09	2.78	51.63	2.49	39.64	3.46
Social benefits & transfers	20.81	1.66	22.42	1.47	21.28	1.64	17.86	3.07	16.93	1.91	20.81	1.13	15.69	1.02
Employees' compensation	10.42	0.28	7.99	0.42	9.23	0.35	13.35	0.76	10.46	0.65	12.75	0.48	10.23	0.62
Intermediate consumption	4.95	0.31	3.41	0.25	6.21	0.48	5.03	0.64	4.68	0.66	8.44	0.44	9.94	1.64
Capital formation	2.82	0.24	4.19	0.50	3.89	0.22	4.21	0.92	3.92	0.72	4.35	0.29	2.40	0.55
Subsidies	1.41	0.18	1.64	0.12	1.35	0.14	0.95	0.25	1.06	0.09	1.79	0.58	0.53	0.09
Other	1.87	0.42	1.09	0.48	0.02	0.25	0.44	0.33	1.05	0.28	3.48	0.43	0.85	0.17
Interest burden	6.05	2.18	0.35	0.11	2.79	1.16	3.46	0.94	2.83	1.14	2.51	1.51	2.57	0.57
Primary balance	2.75	1.91	2.34	2.20	1.42	2.38	-1.37	2.28	0.34	3.85	2.60	2.23	-1.09	3.31
Cycl. adj. prim. bal.[2]	2.62	1.76	2.35	1.50	1.14	2.19	-1.58	2.43	-0.51	2.79	2.72	1.69	-1.13	2.63
Fiscal rule index[3]	-0.31	0.42	0.90	0.85	1.12	0.02	-0.43	0.48	1.01	1.16	1.57	1.18	1.45	1.14

[1] All fiscal data were obtained from the centralized national accounts in the Eurostat Statistics Database.

[2] The cyclical correction was obtained using data from AMECO, the annual macro-economic database of the European Commission's Directorate General for Economic and Financial Affairs.

[3] The fiscal rule index (FRI) was designed by the Directorate General for Economic and Financial Affairs (DG ECFIN) of the European Commission. The full database covering national numerical fiscal rules can be downloaded freely from its online "Fiscal governance in the EU Member States" portal.

Table 15: Model Selection Criteria and Tests

Germany:					*Loglikelihood Ratio Tests*			
		AIC	*BIC*	*LLF*	*a.*	*b.*	*c.*	*d.*
a.	*VAR(2)*	-2602.3	-2532.4	1325.2	-	0	0	0
b.	*VAR(4)*	-2631.1	-2508.7	1357.5		-	0	0
c.	*VAR(6)*	-2639.7	-2465.0	1379.9			-	1
d.	*VAR(8)*	-2625.9	-2398.7	1390.9				-

France:					*Loglikelihood Ratio Tests*			
		AIC	*BIC*	*LLF*	*a.*	*b.*	*c.*	*d.*
a.	*VAR(2)*	-2746.1	-2676.0	1397.0	-	0	0	0
b.	*VAR(4)*	-2776.8	-2654.1	1430.4		-	0	0
c.	*VAR(6)*	-2776.2	-2601.0	1448.1			-	0
d.	*VAR(8)*	-2777.4	-2549.6	1466.7				-

Italy:					*Loglikelihood Ratio Tests*			
		AIC	*BIC*	*LLF*	*a.*	*b.*	*c.*	*d.*
a.	*VAR(2)*	-2523.4	-2453.3	1285.7	-	0	0	0
b.	*VAR(4)*	-2554.2	-2431.6	1319.1		-	0	0
c.	*VAR(6)*	-2550.5	-2375.3	1335.3			-	0
d.	*VAR(8)*	-2566.4	-2338.6	1361.2				-

Spain:					*Loglikelihood Ratio Tests*			
		AIC	*BIC*	*LLF*	*a.*	*b.*	*c.*	*d.*
a.	*VAR(2)*	-2407.3	-2337.2	1227.7	-	0	0	0
b.	*VAR(4)*	-2425.5	-2302.9	1254.8		-	0	0
c.	*VAR(6)*	-2414.9	-2239.7	1267.5			-	1
d.	*VAR(8)*	-2404.8	-2177.0	1280.4				-

Belgium:					*Loglikelihood Ratio Tests*			
		AIC	*BIC*	*LLF*	*a.*	*b.*	*c.*	*d.*
a.	*VAR(2)*	-2712.0	-2641.9	1380.0	-	0	0	0
b.	*VAR(4)*	-2731.7	-2609.1	1407.9		-	1	0
c.	*VAR(6)*	-2716.8	-2541.6	1418.4			-	0
d.	*VAR(8)*	-2752.1	-2524.4	1454.1				-

Notes: AIC denotes the Akaike information criterion, BIC denotes the Bayesian information criterion and LLF denotes the loglikelihood function with the maximum likelihood estimates of the corresponding model parameters. The given selection criteria apply to all models in both their reduced-form as well as their recursive form. The model specifications can be compared bilaterally using the loglikelihood ratio test. A “1” dummy indicates that the column model of the test is rejected in favor of the row model of the test with a default 5% tolerance, and vice versa.

Table 16: Root Mean Squared Errors of Simulated Out-of-sample Forecasts

		GDP growth			*Inflation*			*Interest Rate*		
		VAR(4)	*VAR(6)*	*VAR(8)*	*VAR(4)*	*VAR(6)*	*VAR(8)*	*VAR(4)*	*VAR(6)*	*VAR(8)*
Germany:	Full window	0.0193	0.0188	0.0200	0.0029	0.0030	0.0030	0.0034	0.0033	0.0033
	2 quarters	0.0148	0.0153	0.0163	0.0032	0.0031	0.0033	0.0033	0.0030	0.0029
	4 quarters	0.0151	0.0149	0.0164	0.0032	0.0031	0.0033	0.0035	0.0033	0.0033
	8 quarters	0.0203	0.0182	0.0192	0.0030	0.0030	0.0028	0.0035	0.0032	0.0032
France:	Full window	0.0031	0.0030	0.0043	0.0029	0.0028	0.0036	0.0104	0.0105	0.0087
	2 quarters	0.0024	0.0038	0.0047	0.0034	0.0032	0.0032	0.0045	0.0050	0.0051
	4 quarters	0.0021	0.0030	0.0039	0.0034	0.0034	0.0032	0.0056	0.0073	0.0053
	8 quarters	0.0026	0.0032	0.0034	0.0039	0.0039	0.0034	0.0057	0.0069	0.0045
Italy:	Full window	0.0066	0.0088	0.0112	0.0044	0.0049	0.0059	0.0055	0.0058	0.0052
	2 quarters	0.0070	0.0083	0.0135	0.0041	0.0045	0.0046	0.0056	0.0058	0.0053
	4 quarters	0.0066	0.0072	0.0100	0.0046	0.0047	0.0047	0.0056	0.0053	0.0051
	8 quarters	0.0073	0.0086	0.0099	0.0052	0.0054	0.0057	0.0053	0.0052	0.0049
Spain:	Full window	0.0104	0.0073	0.0081	0.0057	0.0058	0.0078	0.0084	0.0131	0.0096
	2 quarters	0.0086	0.0072	0.0071	0.0052	0.0051	0.0060	0.0073	0.0078	0.0089
	4 quarters	0.0109	0.0084	0.0090	0.0052	0.0052	0.0059	0.0106	0.0106	0.0123
	8 quarters	0.0092	0.0087	0.0095	0.0061	0.0063	0.0072	0.0168	0.0175	0.0131
Belgium:	Full window	0.0044	0.0042	0.0046	0.0052	0.0050	0.0063	0.0135	0.0154	0.0144
	2 quarters	0.0037	0.0055	0.0058	0.0053	0.0052	0.0060	0.0055	0.0059	0.0053
	4 quarters	0.0035	0.0043	0.0049	0.0056	0.0057	0.0053	0.0093	0.0099	0.0072
	8 quarters	0.0038	0.0042	0.0041	0.0065	0.0066	0.0060	0.0107	0.0119	0.0088

Notes: Entries are the root mean squared error of forecasts computed for the considered vector autoregression models. Each estimation was done using data from 1980Q1 through the beginning of the forecast period, 2009Q4.

Table 17: Static Fiscal Reaction Function: Alternative Specifications

	Alternative Output Measure: GDP Growth								HAC-robust Standard Errors			
	FE				IV-2SLS				IV-2SLS			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$d_{i,t-1}$	0.02	0.03**	0.02	0.05**	0.03**	0.04***	0.03*	0.05***	0.09***	0.06***	0.05***	0.07***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
$g_{i,t}$	0.42***	0.20**	0.26	0.18**	0.78***	0.27***	0.22	0.23***	0.73***	0.34***	0.43***	0.33***
	(0.07)	(0.08)	(0.23)	(0.08)	(0.09)	(0.08)	(0.14)	(0.08)	(0.08)	(0.08)	(0.11)	(0.09)
$\pi_{i,t}$			0.33				0.26				0.25	
			(0.32)				(0.27)				(0.19)	
$r_{i,t}$			-0.03				-0.01				-0.13	
			(0.20)				(0.19)				(0.11)	
$fri_{i,t}$				0.63*				0.62**				0.64***
				(0.34)				(0.30)				(0.24)
Country FE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Time FE		0.000	0.000	0.000		0.000	0.000	0.000		0.000	0.000	0.000
N^o of Obs.	449	449	282	421	448	448	280	420	397	422	280	394
N^o of Instr.					3	3	5	4	5	3	5	4
Hansen test					0.191	0.038	0.018	0.026	0.000	0.141	0.727	0.269
Reduced F					84.12	39.29	62.17	35.44	166.79	430.13	121.92	361.37
Adjusted R^2	54.1%	66.1%	76.4%	69.5%	50.3%	66.4%	76.8%	70.2%	59.8%	68.7%	77.0%	72.3%

Notes: The dependent variable is the cyclically unadjusted primary budget balance ($pb_{i,t}$) of the respective countries. Standard errors are noted in parentheses: * $p<0.10$, ** $p<0.05$, *** $p<0.01$. Country-clustered standard errors are denoted in columns (1)-(8). Arbitrary heteroskedasticity and arbitrary autocorrelation robust standard errors are reported in columns (9) through (12). Since fixed effects are included, the table states the p-value corresponding to the F-test testing the null hypothesis that all country or time effects are jointly zero. For the instrumental variable regressions the p-values of the Sargan-Hansen tests for overidentifying restrictions are reported, as well as the F-statistic of the reduced form.

Table 18: Dynamic Fiscal Reaction Function: Alternative Output Measure (GDP Growth)

	LSDVC				IV-GMM							
					GMM-diff				GMM-sys			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$pb_{i,t-1}$	0.64***	0.65***	0.68***	0.64***	0.73***	0.83***	0.62***	0.58**	0.62***	0.65***	0.58***	0.61***
	(0.04)	(0.05)	(0.06)	(0.05)	(0.06)	(0.16)	(0.22)	(0.24)	(0.08)	(0.07)	(0.11)	(0.06)
$d_{i,t-1}$	0.04***	0.03***	0.03**	0.04***	0.00	0.03	0.11*	0.12**	-0.02	0.00	-0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.04)	(0.02)	(0.06)	(0.05)	(0.01)	(0.01)	(0.01)	(0.01)
$g_{i,t}$	0.31***	0.09**	0.08	0.09**	0.38***	0.23***	0.38*	-0.07	0.38***	0.26***	0.29***	0.20***
	(0.03)	(0.04)	(0.09)	(0.04)	(0.07)	(0.08)	(0.22)	(0.14)	(0.05)	(0.07)	(0.10)	(0.06)
$\pi_{i,t}$			0.29**	0.09			0.99				-0.02	
			(0.14)	(0.06)			(0.66)				(0.21)	
$r_{i,t}$			-0.03				0.02				0.10	
			(0.12)				(0.34)				(0.09)	
$fri_{i,t}$				0.38**				-0.36				0.40**
				(0.17)				(0.86)				(0.19)
Country FE	0.000	0.000	0.000	0.000								
Time FE		0.000	0.001	0.000		0.010	0.986	0.000		0.000	0.001	0.000
N^o of Obs.	444	444	280	416	415	415	254	387	444	444	280	416
N^o of Instr.					7	11	11	12	14	18	18	20
Hansen J-test					0.484	0.258	0.393	0.128	0.364	0.752	0.520	0.562
Reduced F					11.61	26.31	22.69	12.84	21.02	65.26	33.13	25.57
Goodness-of-fit	73.7%	78.6%	85.1%	81.3%	69.3%	73.2%	27.9%	34.8%	55.8%	67.4%	73.0%	71.6%

Notes: The dependent variable is the cyclically unadjusted primary budget balance ($pb_{i,t}$) of the respective countries. Standard errors are noted in parentheses: * p<0.10, ** p<0.05, *** p<0.01. In columns (1)-(4) bootstrapped standard errors following the bias-corrected alternative by Bruno (2005) are reported. For the IV-GMM models in columns (5)-(12) two-step Windmeijer's (2005) robust standard errors are reported. In the case that fixed effects are present the table states the p-value corresponding to the F-test testing the null hypothesis that all country or time effects are jointly zero. For the instrumental variable regressions the p-values of the Sargan-Hansen tests for overidentifying restrictions are reported, as well as the F-statistic of the reduced form. The goodness-of-fit is the squared correlation coefficient between the actual and predicted values of the primary balance (see e.g. Bloom et al., 2007).

Table 19: Static Fiscal Reaction Function: Comparison of Subsets

	FE			IV-2SLS		
	Core	*Per.*	*Full*	*Core*	*Per.*	*Full*
$d_{i,t-1}$	0.02	0.10**	0.05**	0.04*	0.09***	0.07***
	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)
$g_{i,t}$	0.51**	0.22**	0.28***	0.64***	0.10	0.33***
	(0.20)	(0.09)	(0.08)	(0.16)	(0.12)	(0.11)
$fri_{i,t}$	0.60*	0.61	0.68*	0.57**	0.41	0.64*
	(0.31)	(0.50)	(0.34)	(0.27)	(0.41)	(0.34)
Country FE	0.000	0.000	0.000	0.000	0.000	0.000
Time FE	0.000	0.004	0.000	0.000	0.000	0.000
N^o of Obs.	237	166	403	236	158	394
N^o of Instr.				4	4	4
Hansen test				0.993	0.205	0.281
Reduced F				155.74	48.47	361.37
Adjusted R^2	76.9%	59.3%	70.7%	77.7%	59.3%	72.3%

Notes: The dependent variable is the cyclically unadjusted primary budget balance ($pb_{i,t}$) of the respective countries. Country-clustered standard errors are noted in parentheses: * p<0.10, ** p<0.05, *** p<0.01. Since fixed effects are included, the table states the p-value corresponding to the F-test testing the null hypothesis that all country or time effects are jointly zero. For the instrumental variable regressions the p-values of the Sargan-Hansen tests for overidentifying restrictions are reported, as well as the F-statistic of the reduced form.

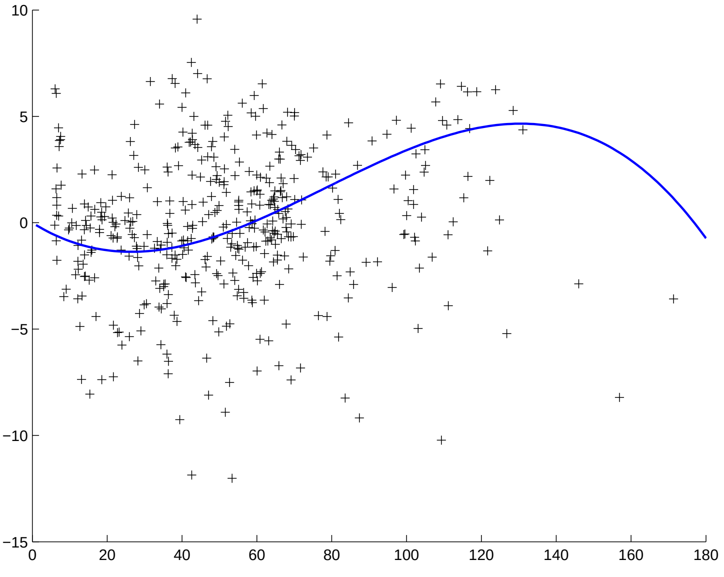
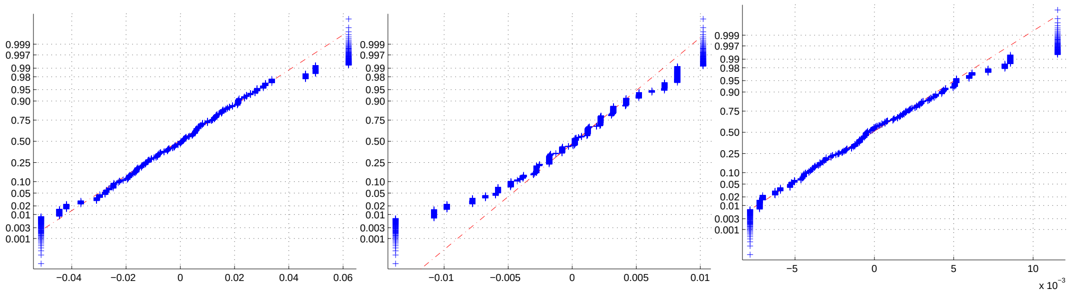


Figure 12: The cyclically unadjusted primary balance as a cubic function of the lagged debt rate for the full panel as estimated in table 8.

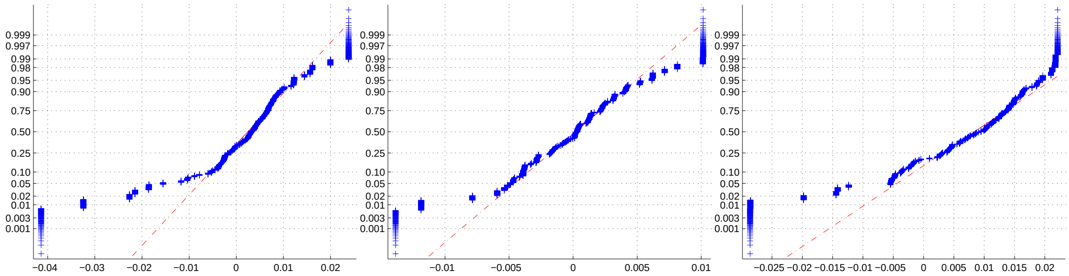
Table 20: Deciles of the Stochastic Public Debt Simulations

	DE					*FR*					*BE*				
	2014	*2015*	*2016*	*2017*	*2018*	*2014*	*2015*	*2016*	*2017*	*2018*	*2014*	*2015*	*2016*	*2017*	*2018*
0%	68.39	55.73	45.92	37.19	30.07	89.17	82.13	77.72	73.94	68.32	99.98	92.30	86.83	82.36	77.89
10%	70.84	62.15	54.63	47.48	41.18	90.51	86.35	83.05	79.62	75.65	101.70	96.29	92.86	89.60	85.39
20%	71.31	63.50	56.39	49.93	44.06	90.87	87.14	84.14	81.02	77.27	102.03	97.36	94.28	91.15	87.52
30%	71.63	64.42	58.04	51.65	45.93	91.10	87.74	85.04	82.02	78.55	102.32	98.09	95.28	92.44	88.93
40%	71.90	65.25	59.27	53.21	47.69	91.30	88.37	85.80	83.00	79.77	102.55	98.75	96.21	93.51	90.36
50%	72.17	66.09	60.49	54.66	49.39	91.49	88.92	86.52	83.80	80.64	102.75	99.36	97.02	94.71	91.45
60%	72.44	66.89	61.80	56.26	51.21	91.70	89.44	87.19	84.59	81.62	102.96	99.94	98.01	95.75	92.78
70%	72.71	67.80	63.01	58.01	53.25	91.90	90.00	87.93	85.61	82.64	103.17	100.61	98.89	96.79	94.18
80%	73.03	69.02	64.70	60.08	55.77	92.12	90.66	88.87	86.57	83.93	103.41	101.37	100.03	98.43	95.98
90%	73.49	70.53	66.96	63.20	59.24	92.45	91.61	90.05	87.97	85.51	103.81	102.50	101.66	100.34	98.37
100%	75.50	77.58	78.17	79.59	76.64	94.80	95.99	95.67	94.92	94.41	105.25	107.40	109.28	109.46	110.90

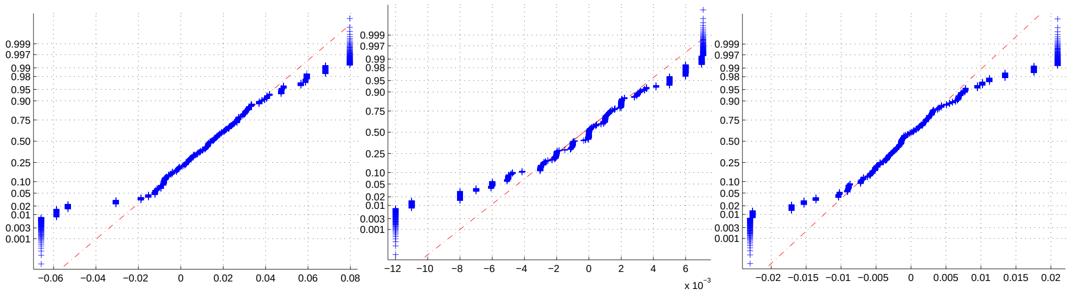
	IT					*ES*				
	2014	*2015*	*2016*	*2017*	*2018*	*2014*	*2015*	*2016*	*2017*	*2018*
0%	118.20	98.54	77.49	60.67	46.45	86.67	73.48	63.33	52.55	41.51
10%	122.08	112.24	100.85	88.78	79.09	90.27	83.51	76.10	68.89	61.88
20%	123.00	115.91	106.85	96.58	88.87	90.93	85.79	79.54	73.47	67.14
30%	123.62	118.26	111.12	103.28	96.52	91.41	87.65	82.34	77.17	71.40
40%	124.18	120.17	115.00	108.61	103.71	91.78	89.12	85.03	79.93	75.24
50%	124.62	122.19	118.41	113.76	109.99	92.17	90.55	87.16	82.93	78.81
60%	125.10	124.14	122.00	119.11	118.47	92.56	92.05	89.50	85.85	82.31
70%	125.61	126.32	126.07	125.25	126.01	92.94	93.63	92.05	89.40	86.39
80%	126.24	128.78	130.86	132.59	135.54	93.41	95.58	95.25	93.36	90.89
90%	127.00	131.87	137.63	143.04	151.69	94.04	98.40	100.42	100.29	98.96
100%	130.36	149.49	178.90	227.08	298.13	97.66	111.60	134.89	146.71	157.26



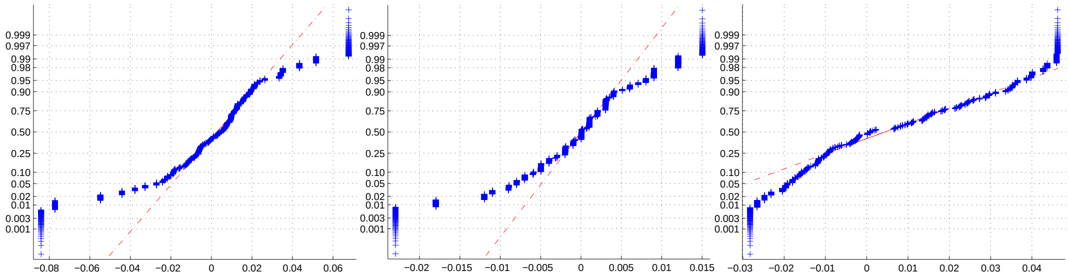
(a) Germany: real GDP **(b) Germany:** inflation **(c) Germany:** interest rate



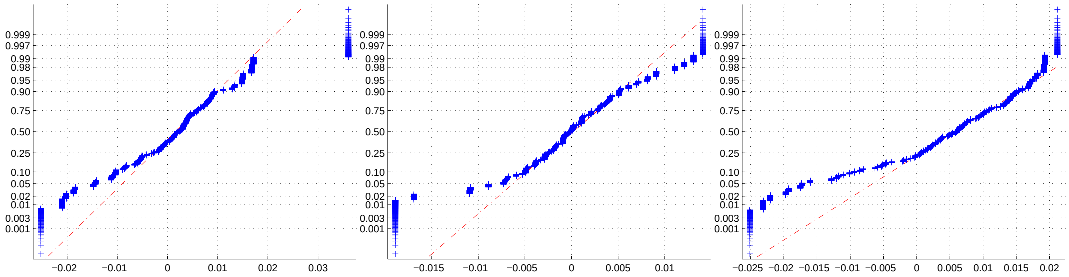
(d) France: real GDP **(e) France:** inflation **(f) France:** interest rate



(g) Italy: real GDP **(h) Italy:** inflation **(i) Italy:** interest rate



(j) Spain: real GDP **(k) Spain:** inflation **(l) Spain:** interest rate



(m) Belgium: real GDP **(n) Belgium:** inflation **(o) Belgium:** interest rate

Figure 13: Normal probability plots of the innovations to X_t (at the end of 2018) based on 10.000 block bootstrapped innovations from the estimated models' historic residuals.

Table 21: Decomposition of the Variance of Public Debt

	Macroeconomic Uncertainty								*Policy Uncertainty*		*Total Uncertainty*	
	Individual Effects			*Correlation*			*Full*					
	g_t	π_t	r_t	$\{g_t, \pi_t\}$	$\{g_t, r_t\}$	$\{\pi_t, r_t\}$	$\{g_t, \pi_t, r_t\}$	in %	$\{pb_t\}$	in %		
Germany:												
2014	0.95	0.38	0.38	1.01	1.02	0.54	1.08	2%	0.82	1%	1.90	3%
2015	3.13	0.74	0.42	3.15	3.16	0.86	3.30	5%	0.96	1%	4.26	7%
2016	4.62	1.20	0.52	4.67	4.69	1.26	4.85	8%	1.18	2%	6.03	10%
2017	5.79	1.65	0.56	5.85	5.87	1.68	6.04	12%	1.47	3%	7.51	14%
2018	6.66	2.06	0.57	6.71	6.66	2.08	6.92	15%	1.80	4%	8.72	19%
France:												
2014	0.51	0.22	0.51	0.54	0.71	0.54	0.75	1%	0.35	0%	1.10	1%
2015	1.86	0.43	0.74	1.82	1.92	0.85	1.98	2%	0.55	1%	2.53	3%
2016	2.59	0.43	0.94	2.56	2.75	1.01	2.77	3%	0.73	1%	3.50	4%
2017	3.04	0.52	1.31	3.00	3.25	1.40	3.37	4%	0.86	1%	4.23	5%
2018	3.43	0.91	1.72	3.47	3.69	1.99	3.92	5%	1.07	1%	4.99	6%
Italy:												
2014	1.59	0.08	1.06	1.63	1.87	1.04	1.88	2%	0.44	0%	2.32	2%
2015	7.36	0.45	2.67	7.44	7.64	2.60	7.75	6%	0.31	0%	8.06	7%
2016	13.68	1.22	5.84	13.86	14.79	5.66	14.72	13%	0.43	0%	15.15	13%
2017	19.29	2.27	10.80	19.67	22.34	10.37	22.08	21%	-0.16	0%	21.92	21%
2018	24.78	3.78	16.19	25.70	30.35	15.65	30.26	30%	-0.81	-1%	29.45	29%
Spain:												
2014	1.16	0.49	0.85	1.22	1.41	0.94	1.52	2%	1.03	1%	2.55	3%
2015	5.61	1.09	1.31	5.70	5.72	1.71	5.91	6%	0.96	1%	6.87	7%
2016	8.86	1.77	1.77	9.09	9.02	2.54	9.40	10%	1.20	1%	10.60	12%
2017	11.20	2.63	2.25	11.66	11.38	3.49	11.99	14%	1.54	2%	13.53	16%
2018	13.01	3.51	2.78	13.60	13.06	4.49	13.88	16%	2.19	3%	16.07	19%
Belgium:												
2014	0.49	0.50	0.48	0.69	0.69	0.65	0.83	1%	0.66	1%	1.49	1%
2015	2.11	0.88	0.60	2.32	2.20	1.06	2.37	2%	0.82	1%	3.19	2%
2016	3.24	0.94	0.82	3.34	3.32	1.20	3.41	4%	0.97	1%	4.38	4%
2017	3.84	1.33	1.27	4.01	4.04	1.79	4.22	5%	1.17	1%	5.39	5%
2018	4.40	1.91	1.60	4.70	4.53	2.40	4.95	6%	1.46	2%	6.41	6%

Notes: Figures denote standard deviations of the debt rate d_t under different scenarios. The first three columns are simulated under the assumption that only the corresponding column of the respective macro variable remains non-zero in the factorized variance-covariance matrix. In the following columns the number of non-zero columns is increased stepwise. The seventh and eight columns represent the standard deviation of the debt rate found under the full variance-covariance specified by equations (4) and (5), both in absolute terms and as a percentage of the average debt rate simulated. Finally, policy uncertainty is added to the reaction function and is also allowed to counterbalance macro uncertainty.

References

Afonso, A. and Hauptmeier, S. (2009). Fiscal behaviour in the European Union: rules, fiscal decentralization and government indebtedness (ECB Working Paper 1054).

Anderson, T. G. and Hsiao, C. (1982). Formulation and estimation of dynamic models using panel data. *Journal of Econometrics*, 18(1):47–82.

Arellano, M. and Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *Review of Economic Studies*, 58(2):277–297.

Bacchiocchi, E., Borghi, E., and Missale, A. (2011). Public Investment under Fiscal Constraints. *Fiscal Studies*, 32(1):11–42.

Barnhill, T. M. and Kopits, G. (2003). Assessing Fiscal Sustainability Under Uncertainty (IMF Working Paper 03/79).

Berti, K. (2013). Stochastic public debt projections using the historical variance-covariance matrix approach for EU countries (European Commission Economic Papers 480).

Bloom, N., Bond, S., and Van Reenen, J. (2007). Uncertainty and Investment Dynamics. *Review of Economic Studies*, 74(2):391–415.

Blundell, R. W. and Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics*, 87(1):115–143.

Bohn, H. (1995). The Sustainability of Budget Deficits in a Stochastic Economy. *Journal of Money, Credit and Banking*, 27(1):257–271.

Bohn, H. (1998). The Behavior of US Public Debt and Deficits. *The Quarterly Journal of Economics*, 113(3):949–963.

Bruno, G. (2005). Approximating the bias of the LSDV estimator for dynamic unbalanced panel data models. *Economics Letters*, 87(3):361–366.

Budina, N. and van Wijnbergen, S. (2008). Quantitative Approaches to Fiscal Sustainability Analysis: A Case Study of Turkey since the Crisis of 2001. *The World Bank Economic Review*, 23(1):119–140.

Buiter, W. H., Corsetti, G., and Roubini, N. (1993). Excessive Deficits: Sense and Nonsense in the Treaty of Maastricht. *Economic Policy*, 8(16):57–100.

Burger, P., Stuart, I., Jooste, C., and Cuevas, A. (2011). Fiscal sustainability and the fiscal reaction function for South Africa (IMF Working Paper 11/69).

Carnot, N. and de Castro, F. (2015). The Discretionary Fiscal Effort: an Assessment of Fiscal Policy and its Output Effect (European Commission Economic Papers 543).

Celasun, O., Debrun, X., and Ostry, J. D. (2007). Primary Surplus Behavior and Risks to Fiscal Sustainability in Emerging Market Countries: A "Fan-Chart" Approach. *IMF Staff Papers*, 53(3):401–425.

Cevik, S. and Teksoz, K. (2014). Deep Roots of Fiscal Behavior (IMF Working Paper 14/45).

Chalk, N. and Hemming, R. (2000). Assessing Fiscal Sustainability in Theory and Practice (IMF Working Paper 00/81).

Cherif, R. and Hasanov, F. (2012). Assessing Fiscal Sustainability Under Uncertainty (IMF Working Paper 12/230).

Claeys, P. (2006). Policy mix and debt sustainability: evidence from fiscal policy rules. *Empirica*, 33(2):89–112.

Claeys, P. (2008). Rules, and their effects on fiscal policy in Sweden. *Swedish Economic Policy Review*, 15(1):7–47.

Claeys, P., Ramos, R., and Suriñach, J. (2008). Fiscal sustainability across government tiers. *International Economics and Economic Policy*, 5(1):139–163.

Debrun, X., Moulin, L., Turrini, A., Ayuso-i Casals, J., and Kumar, M. S. (2008). Tied to the mast? National fiscal rules in the European Union. *Economic Policy*, 23(54):297–362.

di Giovanni, J. and Gardner, E. (2008). A Simple Stochastic Approach to Debt Sustainability Applied to Lebanon (IMF Working Paper 08/97).

EC (2009). *Public Finances in EMU.* European Commission, Directorate-General for Economic and Financial Affairs, Brussels, Belgium.

EC (2011). *Public Finances in EMU.* European Commission, Directorate-General for Economic and Financial Affairs, Brussels, Belgium.

EC (2012). *Fiscal Sustainability Report 2012.* European Commission, Directorate-General for Economic and Financial Affairs, Brussels, Belgium.

ECB (2007). From Government Deficit to Debt: Bridging the Gap (ECB Monthly Bulletin April 2007).

Fatás, A. and Mihov, I. (2012). Fiscal Policy as a Stabilization Tool. *The B.E. Journal of Macroeconomics*, 12(3):1–68.

Galí, J. and Perotti, R. (2003). Fiscal policy and monetary integration in Europe. *Economic Policy*, 18(37):533–572.

Garcia, M. and Rigobon, R. (2004). A risk management approach to emerging market's sovereign debt sustainability with an application to Brazilian data (NBER Working Paper 10336).

Gavin, M. and Perotti, R. (1997). Fiscal policy in latin america. In Bernanke, B. S. and Rotemberg, J. J., editors, *NBER Macroeconomics Annual Volume 12*, pages 11–72. MIT Press, Cambridge, MA, U.S.A.

Ghosh, A. R., Kim, J. I., Mendoza, E. G., Ostry, J. D., and Qureshi, M. S. (2013a). Fiscal fatigue, fiscal space and debt sustainability in advanced economies. *The Economic Journal*, 123(1):F4–F30.

Ghosh, A. R., Ostry, J. D., and Qureshi, M. S. (2013b). Fiscal space and sovereign risk pricing in a currency union. *Journal of International Money and Finance*, 34(3):131–163.

Girouard, N. and André, C. (2005). Measuring cyclically-adjusted budget balances for OECD countries (OECD Economics Department Working Paper 434).

Golinelli, R. and Momigliano, S. (2009). The Cyclical Reaction of Fiscal Policies in the Euro Area: The Role of Modelling Choices and Data Vintages. *Fiscal Studies*, 30(1):39–72.

Hallerberg, M., Strauch, T., and von Hagen, J. (2007). The design of fiscal rules and forms of governance in European Union countries. *European Journal of Political Economy*, 23(2):338–359.

IMF (2003). *Sustainability Assessment - Review of Application and Methodological Refinements.* International Monetary Fund, Policy Development and Review Department, Washington, D.C., U.S.A.

IMF (2012). *World Economic Outlook.* International Monetary Fund, World Economic Studies Division, Washington, D.C., U.S.A.

in 't Veld, J., Pagano, A., Ratto, M., Roeger, W., and Szekely, I. P. (2012). Sovereign debt sustainability scenarios based on an estimated model for Spain (European Commission Economic Papers 466).

Jonung, L. B. and Larch, M. (2006). Improving fiscal policy in the EU: the case for independent forecasts. *Economic Policy*, 21(47):491–534.

Jorion, P. (2007). *Value at Risk: The New Benchmark for Managing Financial Risk.* McGraw-Hill, New York, N.Y., U.S.A.

Kempkes, G. (2012). Cyclical adjustment in fiscal rules: some evidence on real-time bias for EU-15 countries (Deutsche Bundesbank Discussion Paper 15).

Krogstrup, S. and Wälti, S. (2008). Do fiscal rules cause budgetary outcomes? *Public Choice*, 136(1):123–138.

Larch, M. and Turrini, A. (2009). The cyclically-adjusted budget balance in EU fiscal policy making: A love at first sight turned into a mature relationship (European Commission Economic Papers 374).

Luechinger, S. and Schaltegger, C. A. (2013). Fiscal rules, budget deficits and budget projections. *International Tax and Public Finance*, 20(5):785–807.

Mauro, P., Romeu, R., Binder, A., and Zaman, A. (2013). *A Modern History of Fiscal Prudence and Profligacy (IMF Working Paper 13/5).*

Medeiros, J. (2012). Stochastic debt simulation using VAR models and a panel fiscal reaction function: results for a selected number of countries (European Commission Economic Papers 459).

Mendoza, E. G. and Ostry, J. D. (2008). International evidence on fiscal solvency: Is fiscal policy "responsible"? *Journal of Monetary Economics*, 55(6):1081–1093.

Mourre, G., Astarita, C., and Princen, S. (2014). Adjusting the budget balance for the business cycle: the EU methodology (European Commission Economic Papers 536).

Mourre, G., Isbaoiu, G.-M., Paternoster, D., and Salto, M. (2013). The cyclically-adjusted budget balance used in the EU fiscal framework: an update (European Commission Economic Papers 478).

Nickell, S. (1981). Biases in Dynamic Models with Fixed Effects. *Econometrica*, 49(6):1417–1426.

Perotti, R. (2007). Fiscal Policy in Developing Countries: A Framework and Some Questions (The World Bank Policy Research Working Paper 4365).

Roodman, D. (2009a). A Note on the Theme of Too Many Instruments. *Oxford Bulletin of Economics and Statistics*, 71(1):135–158.

Roodman, D. (2009b). How to do xtabond2: An introduction to difference and system GMM in Stata. *The Stata Journal*, 9(1):86–136.

Servén, L. (2007). Fiscal Rules, Public Investment, and Growth (World Bank Policy Research Working Paper 4382).

Stock, J. H. and Watson, M. W. (2006). *Introduction to Econometrics.* Pearson, New York, NY, U.S.A.

Stock, J. H. and Watson, M. W. (2008). Heteroskedasticity-robust standard errors for fixed effects panel data regression. *Econometrica*, 76(1):155–174.

Tanner, E. and Samake, I. (2008). Probabilistic Sustainability of Public Debt: A Vector Autoregression Approach for Brazil, Mexico, and Turkey. *IMF Staff Papers*, 55(1):149–182.

Theofilakou, N. and Stournaras, Y. (2012). Government solvency and financial markets: Dynamic panel estimates for the European Monetary Union. *Economics Letters*, 115(1):130–133.

Tielens, J., van Aarle, B., and Van Hove, J. (2014). Effects of Eurobonds: a stochastic sovereign debt sustainability analysis for Portugal, Ireland and Greece (CES Discussion Paper 14.10).

van Ewijk, C., Lukkezen, J., and Rojas-Romagosa, H. (2013). Early-warning indicators for debt sustainability (CPB Policy Brief 2013/08).

Verbeek, M. (2004). *A guide to modern econometrics.* John Wiley & Sons, Chichester, U.K.

von Hagen, J. (2010). Sticking to fiscal plans: the role of institutions. *Public Choice*, 144(3):487–503.

Windmeijer, F. (2005). A finite sample correction for the variance of linear efficient two-step GMM estimators. *Journal of Econometrics*, 126(1):25–51.