How Sustainable are Public Debt Levels in Emerging Europe?
Evidence for Selected CESEE Countries from a Stochastic Debt Sustainability Analysis

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Abstract

Traditional public debt sustainability analyses (DSA) are based on a debt accumulation accounting identity and result in a single debt projection path. Uncertainty related to these projections is only captured by a small set of alternative scenarios assuming isolated shocks to individual variables. This paper goes beyond this traditional approach and uses a probabilistic approach to DSA proposed by Celasun et al. (2007) by estimating a probability distribution of public debt projections. These ensue by adding two additional building blocks to the debt accounting identity: endogeneous fiscal policy through an estimated fiscal reaction function, and a simulation of macroeconomic shocks based on the estimated joint distribution of disturbances of an unrestricted VAR model of macroeconomic variables. To the best of our knowledge, we are the first ones to apply this methodology explicitly to a group of CESEE countries, namely to the Czech Republic, Poland, Hungary and Slovakia. Moreover, compared to earlier applications to industrialized countries, we modify this methodology to account for a wider set of fiscal policy determinants and for possible non-stationarity of the time series. We find that, even though central projections suggest that public debt in these countries is broadly sustainable over the period 2012-2016, the joint dynamics of macroeconomic shocks, as well as fiscal policy itself pose considerable risks to these projections and taking them into account can help inform policy-making.

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1 Motivation and Background

Given comparatively low shares of gross public debt in GDP in most countries of Central, Eastern and Southeastern Europe (CESEE), one might take the view that the sustainability of public debt positions is not really jeopardized in this region. However, the 2008-2009 recession taught us that, first, under extreme circumstances, debt ratios can increase very quickly to unexpectedly high levels (see Table 1) and, second, the main risk to sustainability of public sector debt positions in emerging market economies may arise or start out from liquidity problems. In fact, several CESEE countries were confronted with strongly deteriorating financing conditions when the global financial crisis hit the region after the collapse of Lehman Brothers with the consequence that some of them lost market access and had thus to resort to the IMF and the EU for multilateral assistance (see Eller, Mooslechner and Ritzberger-Grünwald, 2012). Moreover, econometric investigations of debt limits indicate that the tolerance threshold for public indebtedness is lower for emerging economies than for advanced economies. The IMF (2003), for instance, showed that public debt was clearly below 60% of GDP in every second sovereign default case recorded in emerging market economies in the past.

Table 1 about here

Alvarado et al. (2004) refer to further reasons which may justify a different assessment of fiscal sustainability in emerging economies compared to advanced economies: time series of economic and fiscal data are usually short and contain structural breaks; emerging markets often have limited capacity to raise taxes (e.g. due to a large informal sector); they have a volatile revenue base and also volatile expenditures; they are subject to large external shocks, both real and financial, that increase the volatility of GDP growth and debt service and they are often characterized by a high share of liabilities denominated in foreign currency.

Conceptually, debt sustainability is given as long as debt does not accumulate at a considerably faster rate than the government's capacity to service it (without implausibly large policy adjustments, renegotiating or defaulting; see Ostry et al., 2010). In other words, sustainability is given as long as debt paths are perceived as being unlikely to explode under a range of reasonable scenarios. Most empirical approaches to measure debt sustainability are based on a debt accumulation accounting identity which, in turn, is derived from the government's intertemporal budget constraint (see, among others, Bohn, 1998).

Depending on the chosen time horizon, the literature distinguishes three different forward-looking approaches to measure debt sustainability: (1) short-term approaches, consisting of the examination of refinancing profiles to assess liquidity and roll-over risks; (2) medium-term approaches, consisting of the projection of debt trajectories for about 5-15 years ahead and changes in these debt trajectories under different scenarios; and (3) long-term approaches, which calculate sustainability gaps for up to several decades ahead, basically examining the budgetary impact of demographic changes such as ageing societies (e.g. Balassone et al., 2011). For our analysis we have chosen to implement a methodology that belongs to the second class of these forward-looking approaches.

From a methodological point of view, we address some of the drawbacks that have been raised with regard to the traditional, deterministic, DSA framework of the IMF (see IMF, 2011), which calculates alternative scenarios (in comparison to the benchmark projection) by assuming a permanent shock based on a fixed share of the standard deviation of historical data. Most importantly, there is no feedback between the individual macroeconomic variables that could multiply the effect of the shocks beyond a simple sum of single isolated shocks to each variable. This can lead to an underestimation of risks to the debt path, which has also been pointed out by the IMF itself (2008)[3]. More recently, Celasun et al. (2007) proposed a stochastic DSA approach based on a simulation algorithm for the path of public debt under shock configurations, which are drawn from a joint distribution and capture, in contrast to the deterministic DSA, the second-round interactions among the shocked variables. They combine the estimation of a fiscal reaction function (primary balance as a function of debt and output gap) with the estimation of an unrestricted VAR model for non-fiscal macroeconomic variables to come up with projections of future debt paths. The baseline projection of the debt-to-GDP ratio is subject to both random fiscal and macro shocks, whereby an endogenous response of the fiscal policymakers to macro shocks is allowed for. Frequency distributions of the debt ratio can then be obtained for each year of projection and used to draw fan charts.

The contribution of our paper is twofold. First, to the best of our knowledge, there is no explicit application of this stochastic DSA (SDSA) framework to CESEE economies and we believe that the projection of debt paths, subject to a wide range of possible macroeconomic and fiscal shocks, is an appropriate way to account for the comparatively high economic volatility in this region. Second, we try to augment the approach of Celasun et al. (2007) by accounting for a wider set of fiscal policy determinants in the fiscal reaction function and, even though we also utilize an unrestricted VAR(1) model (given the limitations of the short time series at hand), we attempt to improve the model by addressing the properties of the underlying time series, in particular their non-stationarity.

The remainder of this paper is structured as follows: Section 2 defines debt sustainability and delineates the building blocks of the chosen SDSA framework. Section 3 shows the empirical specification and the results for the estimation of the fiscal reaction function. Section 4 discusses the structure and the selection of the VAR model for the non-fiscal macroeconomic determinants of public debt dynamics. Section 5 illustrates by means of fan charts the core results of our paper: the projected public debt paths for four CESEE economies (Czech Republic, Hungary, Poland and Slovakia) until 2016 under different scenarios. Section 6 stresses some caveats related to the SDSA approach and points to further research necessities in the field. Finally, the basic findings and their implications for policymaking are summarized in section 7. Definitions and sources of the data used in sections 3 and 4 are shown in the Appendix (Table A.1).

[3] *"It is important to emphasize that the results are not full-fledged scenarios, as there is no interaction among variables. […]This implies the need to interpret the stress tests with a grain of salt."* (IMF, 2008, p. 6).

2 How to Define Debt Sustainability and Description of the Chosen Methodological Framework

2.1 Definition of Debt Sustainability

Consider the following law of motion for the evolution of public debt over time:

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

where D_t is the stock of public debt maturing at the end of period t, i_t denotes the one-period nominal interest rate, $PB_t = R_t - G_t$ is the primary balance (the difference between total government revenues and non-interest government spending), and S_t represents stock-flow adjustments (e.g. contingent liabilities or extra-revenue stemming from privatizations).

Assuming that $S_t = 0$ and dividing equation (1) by nominal GDP (price level times real GDP) yields:

$$\frac{D_t}{P_t Y_t} = \frac{(1+i_t)}{(1+\pi_t)(1+g_t)} \frac{D_{t-1}}{P_{t-1}Y_{t-1}} - \frac{PB_t}{P_t Y_t} = d_t = \frac{(1+r_t)}{(1+g_t)} d_{t-1} - p_t, \quad (2)$$

where d_t is the debt-to-GDP ratio, p_t is the primary balance-to-GDP ratio, r_t is the ex-post real interest rate, π_t is the inflation rate and g_t is the real GDP growth rate. Under the assumption that r_t, g_t and p_t remain constant over time, it can be seen from equation (2) that the debt-to-GDP ratio remains stable as long as $\theta = \frac{(1+r)}{(1+g)} \leq 1$. If $\theta > 1$, i.e. $r > g$ (the often quoted positive interest-growth differential), a sufficiently positive primary balance-to-GDP ratio is needed to keep the debt ratio stable. The assumption of constant variables over time is, however, not very realistic; our approach allows for stochastic changes in these variables during the forecasting horizon.

As already emphasized in the introduction, debt sustainability requires a non-exploding path for the debt-to-GDP ratio over time. Strict sustainability would require, first, that debt is repaid in the very end, i.e. $\lim_{t\to\infty} E(d_t) = 0$ (no-Ponzi-game condition) and, second, that in a stochastic world the distribution of all possible realizations of d_t does not exceed any finite limit, i.e. the expected variance of d_t is asymptotically finite ($\lim_{t\to\infty} E\left(\sigma^2_{d_t}\right) < \infty$). Unfortunately, these definitions are not very useful in empirical applications given that it is not possible to make forecasts over an infinite horizon. Ferrucci and Penalver (2003) thus proposed a weaker definition: debt is sustainable as long as there is a reasonably high probability (say 75%) that d_t is *not* higher at the end of the forecast horizon than at the beginning. When interpreting our results in Section 5, we follow this definition.

2.2 Building Blocks of the Stochastic Debt Sustainability Analysis Framework

The SDSA framework consists of three building blocks (Figure 1): a fiscal reaction function, a VAR model and the traditional debt accounting identity. The first and the last blocks use annual data, as reliable fiscal accrual variables and control variables in the fiscal reaction function (e.g. institutional variables) are better available on an annual basis. The VAR model, on the other hand, works with quarterly macroeconomic data, which are annualized before entering the debt identity. This feature makes the framework suitable for emerging markets economies, as for these countries the available economic time series are often short and utilizing higher-frequency data thus helps to overcome this problem to a certain extent. In this section we briefly discuss each of these building blocks and follow the notation of Celasun et al. (2007).

Figure 1 about here

Debt-deficit stock-flow identity:

To account for the considerable share of public debt denominated in foreign currency in the countries under investigation, we rewrite equation (2) for a sovereign issuing bonds in foreign currency:

$$d_t \equiv (1+g_t)^{-1}\left[\left(1+r_t^f\right)(1+\Delta z_t)d_{t-1}^f + (1+r_t)d_{t-1}^d\right] - p_t, \qquad (3)$$

where, besides the notation already explained for equation (2), r_t^f denotes the real foreign interest rate, r_t the real domestic interest rate, Δz_t is the rate of depreciation of the (log of the) real effective exchange rate, d_{t-1}^f is the foreign-currency denominated debt-to-GDP ratio and d_{t-1}^d captures debt denominated in domestic currency.

To come up with a projection of d_t for future periods (our forecasts run from 2012 until 2016), we first need to obtain projections of the underlying debt identity variables in equation (3). In the SDSA framework, forecasts of the primary balance are obtained through a fiscal reaction function and forecasts of the macroeconomic variables ($r_t^f, r_t, g_t, \Delta z_t$) are obtained through a VAR model.

Fiscal reaction function (FRF):

The fiscal reaction function endogenizes fiscal policy so that the policy maker reacts to the business cycle, past level of debt and a set of controls (e.g. inflation or the election cycle). Policy persistence is captured by the lagged primary balance term on the right-hand side. Fiscal policy thus becomes another source of uncertainty to the debt level, in as much as it deviates from the behavior predicted by the fiscal reaction function. We estimate the reaction function as follows:

$$p_{i,t} = \alpha_0 + \delta p_{i,t-1} + \rho d_{i,t-1} + \sum_{k=0}^{1} \gamma_k og_{i,t-k} + X_{i,t}\beta + \eta_i + \varepsilon_{i,t}, \qquad (4)$$
$$t = 1, \dots, T, \quad i = 1, \dots, N$$

where $p_{i,t}$ is the ratio of the primary balance to GDP in country *i* and year *t*, $d_{i,t-1}$ is the public debt-to-GDP ratio observed at the end of the previous year, $og_{i,t}$ is the output gap, η_i is an unobserved country fixed-effect, $X_{i,t}$ is a vector of control variables and $\varepsilon_{i,t} \sim \mathrm{iid}(0, \sigma^2{}_\varepsilon)$.

Simulated forecasts of the primary balance:

The estimated FRF is used to generate forecasts of the primary balance for the period 2012-2016[4], which are obtained as follows:

$$\hat{p}_{i,t+\tau} = \Lambda_{i,t+\tau} + \hat{\delta} p_{i,t+\tau-1} + \hat{\rho} d_{i,t+\tau-1} + \sum_{k=0}^{1} \hat{\gamma}_k og_{i,t+\tau-k} + \varphi_{i,t+\tau} \quad (4.1)$$

$$\tau = 1, \dots, 5$$

$$\Lambda_{i,t+\tau} = \hat{p}_{i,t} - \hat{\delta} p_{i,t-1} - \hat{\rho} d_{i,t-1} - \sum_{k=0}^{1} \hat{\gamma}_k og_{i,t-k} = \hat{\alpha}_0 + X_{i,t}\hat{\beta} + \hat{\eta}_i \quad (4.1.1)$$

$$\varphi_{i,\,t+\tau} = \sigma^2_{\left(\eta_i + \varepsilon_{i,\,t}\right)} \upsilon_{t+\tau} \quad (4.1.2)$$

$$\upsilon_{t+\tau} \sim N(0,1) \text{ and } \varphi_{i,\,t+\tau} \sim N\left(0,\, \sigma^2_{\left(\eta_i + \varepsilon_{i,\,t}\right)}\right) \quad (4.1.3)$$

$\Lambda_{i,t+\tau}$ captures the impact of all determinants of the primary surplus other than the lagged primary balance, lagged debt and the output gap and represents a country-specific constant component of the primary balance.

$\varphi_{i,t+\tau}$ is a random draw from a set of 1000 shocks with a mean-zero normal distribution and a variance equal to the country-specific variance of the FRF residuals $\left(\eta_i + \varepsilon_{i,t}\right)$. A set of 1000 forecasts of the primary balance, in line with these stochastic shocks, is generated from equation (4.1).

Note that the primary balance forecasts also depend on future realizations of the output gap, which, in turn, are affected by the macroeconomic shocks obtained with the VAR model (as illustrated in Fig. 1). This implies that the fiscal policymaker responds to macro shocks during the forecasting horizon and therefore – in contrast to the deterministic DSA – we allow for an endogenous fiscal policy.

Unrestricted VAR model for non-fiscal determinants of public debt dynamics:

For each country a VAR model with the macroeconomic determinants of debt dynamics is estimated using quarterly data:

$$Y_t = \gamma_0 + \sum_{k=1}^{p} \gamma_k Y_{t-k} + \xi_t, \quad (5)$$

where $Y_t = \left(r_t^f, r_t, g_t, \Delta z_t\right)$, γ_k is a vector of coefficients and $\xi_t \sim N(0,\Omega)$ is a vector of well-behaved error terms with variance-covariance matrix Ω.

Simulated forecasts of the macroeconomic variables belonging to the VAR model:

Based on the variance-covariance matrix Ω of the VAR model, a sequence of 1000 random vectors $\hat{\xi}_\tau$ is generated in a similar vein as in the FRF simulations. Thus, the sequence of random vectors corresponds to $\hat{\xi}_{t+\tau} = W\upsilon_{t+\tau},\ \forall \tau \in [t+1, T]$, where $\upsilon_{t+\tau} \sim N(0,1)$ and $\Omega = W'W$ ($\upsilon_{t+\tau}$ is a random draw from a standard normal distribution and W is the Choleski factorization of Ω). Consequently, a set of 1000 forecasts of the macroeconomic variables is generated by the VAR model such that a joint dynamic response of the variables is warranted.

[4] Implicit assumption: the parameters of the fiscal reaction function, which we estimated for the period 1995-2011, continue to be valid also during the forecasting period 2012-2016.

$$\widehat{Y_{t+\tau}} = \widehat{\gamma_0} + \widehat{\gamma_1} Y_{t+\tau-1} + \widehat{\xi_{t+\tau}} \qquad (5.1)$$
$$\tau = 1, \dots, 5$$

The projections of the macroeconomic variables, containing the stochastic shocks, are then annualized and – together with the primary balance forecasts containing fiscal stochastic shocks – enter the debt-deficit stock-flow identity to generate the debt projections.

3 Average Fiscal Policy Patterns

3.1 Empirical Specification of the Fiscal Reaction Function

The main goal of estimating the fiscal reaction function (equation (4)) lies in obtaining a prediction of the primary budget balance-to-GDP ratio. We estimate the fiscal reaction function (FRF) for a panel of eight CESEE countries (Bulgaria, Croatia, Czech Republic, Hungary, Poland, Romania, Slovakia, Slovenia) and a maximum of 17 years (1995-2011). We used for the FRF estimation a broader sample of rather homogeneous countries (in line with Staehr, 2007; Abiad and Ostry, 2005; or Ostry et al., 2010) than for the whole SDSA exercise to address the lack of sufficiently long fiscal time series in the countries under consideration.

The fiscal reaction function shows the response of the primary budget balance-to-GDP ratio[5] to a set of macroeconomic and institutional variables, of which the debt-to-GDP ratio and the output gap are the most important ones. A positive response of the primary balance to lagged debt can be expected if buoyant debt dynamics are corrected. If the primary balance were related positively to the output gap, favorable economic developments would improve the budgetary position of a country (e.g. via boom-induced revenue windfalls) – indicating a countercyclical fiscal response, whereas a negative coefficient would indicate a procyclical and an insignificant coefficient an acyclical fiscal response. We have included lagged output gaps to account for the possible persistent impact of recessions and booms.

To better explain the evolution of and thus to improve the fit of the primary balance ratio, we experimented with the inclusion of various additional explanatory variables, which might potentially induce a reaction by the fiscal policymaker or determine the surplus-generating capacities of a country. Obvious candidates are: (1) the lagged primary balance to account for policy persistence; (2) inflation rate; (3) quality of fiscal institutions, existing fiscal rules; (4) political events like elections: different types of election dummies; (5) foreign business cycle shocks: either via trade openness or via growth differential vis-à-vis main trading partners; or (6) other factors such as revenue windfalls, natural disasters, large-scale infrastructure investments, social security reforms. We included a variety of these control variables in several robustness checks. (1) and (2) remained robust across various specifications. For (3)-(5) we included several indicators, which did not turn out to be significant and therefore are not included in the final estimations (e.g., elections showed the expected negative sign but were only significant at the 80% level). Ideally, one would also

[5] We use, in line with existing literature (e.g. Bohn, 1998 or Ostry et al., 2010), the overall primary balance and not the cyclically adjusted one as dependent variable given that the unadjusted primary balance is relevant for the calculation of the debt evolution. This has, of course, the drawback that we cannot disentangle the policymaker's direct reaction – i.e. the discretionary part – from budgetary items changing automatically due to business cycle fluctuations (automatic stabilizers).

include data / proxies for (6) but due to data constraints, we had to abstain so far from doing so.

We depart from Celasun et al. (2007) by including the lagged primary balance, lagged output gaps or the inflation rate. On the other hand, several additional explanatory variables, which they found significant for a broad set of emerging economies, including the Latin American countries, turned out to be insignificant for our set of CESEE countries (such as institutional variables), which suggests that fiscal policy in the CESEE countries is, to a certain extent, determined by other factors than that of their emerging peers. Moreover, we experimented with different output gap definitions: based on trend GDP and on potential GDP (both from the European Commission) and based on a Hodrick-Prescott filtered GDP series (with a smoothing parameter of 6.25 as recommended by Ravn and Uhlig (2002) for annual figures). The latter has been favored in our benchmark regression.

The lagged primary balance has been included to appropriately account for autocorrelation of the residuals – getting a dynamic version of the panel. As it is well established in the literature (e.g. Nickell, 1981), estimates of the lagged dependent variable are likely to be biased in short-*T* samples. Moreover, there are also reasonable arguments that the output gap and the lagged debt ratio are endogenous regressors (e.g. IMF 2003). Therefore, we work – besides the fixed effects panel specification (FE) – also with GMM techniques designed for dynamic panels (system GMM estimator of Blundell and Bond, 1998). Despite the theoretical advantages of the system GMM estimator, we opt in the end for the panel fixed effects estimator (column (2) in Table 2) as our baseline for the subsequent calibrations.

Following considerations guided our choice: First, in the GMM-setting the minimal number of required instruments turns out to be large relative to the number of observations (although we collapsed instruments and used only a limited number of lags of the endogenous variables as instruments). Roodman (2009) stressed that instrument proliferation can overfit endogenous variables, fail to expunge their endogenous components and weaken the power of the Hansen instrument validity test (a telltale sign is the perfect Hansen p-value of 1.0). Second, as also elaborated in Roodman (2009), reliable estimates of the true parameter (of the lagged dependent variable) should lie in or near the "credible" range between pooled OLS and the panel fixed effect estimator. As can be seen in Table 2, the system GMM estimator for δ still comprises in its 95% confidence interval the pooled OLS estimator and thus is not too far away from the credible range. Moreover, considering again a 95% confidence interval around the estimates, the pooled OLS and the fixed effect estimator cannot really be distinguished from each other. Therefore, at least in statistical terms, we cannot argue that the coefficients estimated with the three different methodologies are really different from each other; the bias due to endogeneity in the favored FE-specification should thus be limited.

3.2 Estimation Results

The results of the baseline specification are shown in Table 2. The primary balance shows a great deal of persistence. If the primary budget to GDP ratio improves by 1% of GDP in year *t*, it improves by a further 0.3% of GDP in year *t+1.*

The positive coefficient for the debt-to-GDP ratio implies that the primary balance improves when the last year's debt ratio increased. If debt increases by, say, 10p.p. of GDP, one year later the primary balance strengthens by about 0.5% of GDP (if the debt ratio increases from, e.g., 60% to 70% in year *t*, the primary deficit ratio will shrink from, e.g., -3.0% to -2.5% in year *t+1*). We experiment later also with a stronger response and examine its impact on the evolution of future debt paths.

Several scholars have investigated potential nonlinearities between the primary balance and the debt ratio. An obvious prior would be that the responsiveness of the primary balance is stronger at high than at low debt ratios. Apparently, this hypothesis can only be verified for advanced economies (where the responsiveness is stronger once debt surpassed 80% of GDP, see IMF 2003), while in emerging markets the marginal responsiveness of the primary balance to high debt levels decreases (see Abiad & Ostry, 2005 or IMF, 2003). Possible reasons are: limited fiscal consolidation capacities in EMEs at high debt levels, weak revenue bases (lower yields, higher volatility) due to tax evasion, less effectiveness at controlling government spending during boom times (limited fiscal space). We experimented with a threshold of 40% in column (7) and with a squared debt ratio in column (8) of table 2. Based on these results, we cannot verify that nonlinearities are present in our sample. At least the negative sign for the 40%-debt-threshold is in line with the mentioned evidence for EMEs.

While the contemporaneous output gap shows a positive sign (no matter which method for calculating the output gap has been used), the first lag shows a negative sign. This indicates that the primary budget has a countercyclical effect in the year the business cycle position changes (probably due to a predominant impact of built-in automatic stabilizers), while in the following year we can observe a procyclical response (probably due to delayed discretionary fiscal policy responses). These results do not change when different output gap definitions are used (see columns (3)-(5)). Interestingly, they are particularly pronounced for boom periods while during economic downturns there seems to be no impact (see column (6) where we distinguished periods with positive and negative output gaps).

Table 2 about here

4 Non-fiscal Determinants of Public Debt Dynamics

The aim of the VAR model in the SDSA framework (equation (5)) is to provide a forecast of the macroeconomic determinants of public debt, so that they are contemporaneously correlated and persistent. The SDSA also captures the uncertainty related to this forecast and the resulting debt path. This is achieved by generating not one, but many (in our case one thousand) possible sets of projections of growth, the exchange rate and the domestic and foreign interest rates, which incorporate shocks drawn from the variables' joint distribution, whose mean and variance-covariance matrix have been estimated from the historical data with the VAR model.

For each country, we estimate a VAR model with quarterly macroeconomic data (1995Q1-2011Q4 for Slovakia and the Czech Republic and 1996Q1-2011Q4 for Poland and Hungary; different sample lengths are due to data availability). The length of the available time series imposes a limit on the number of lags in the VAR model we can realistically use; therefore we restrict our analysis to models with one lag only, similarly to Celasun et al. (2007).

Moreover, it has been argued (e.g. Hafer and Sheehan, 1989) that short-lagged VAR models tend to be more accurate, on average, when used for forecasting, than the longer-lagged models. However, adding one or two lags in a robustness check exercise did not substantially change the results, except in the case of Hungary where one additional lag brought the baseline median debt projection down by four percentage points.

Output, interest rates and exchange rates are often found to be non-stationary. We therefore test each time-series used in the model for the presence of a unit root with an Augmented Dickey-Fuller test, supplemented by the Phillips-Perron test. We cannot reject the null hypothesis of non-stationarity of the foreign real interest rate and of the Hungarian domestic real interest rate. These results hold for various sample periods, e.g. when the observations at the beginning or at the end of the sample are cut off based on the consideration that the still ongoing transformation period at the end of the 1990s or the current crisis may distort the results. Differenced series exhibit no unit root, therefore we conclude that they are integrated of order one (I(1)). After similar considerations (i.e. accounting for the effects of the crisis and/or transformation period), we decided to treat the Slovak, Polish and Czech domestic interest rates as stationary, as we did not find strong enough evidence of the presence of a unit-root at the 99% confidence level. The GDP and real effective exchange rate variables enter the models as differences and these differences are found stationary, in line with our expectations.

In a next step we test each of the models (in levels) for co-integration using the Johansen procedure. We do not find evidence for the presence of one or more co-integrating relationships both according to the maximum eigenvalue and the trace test statistics. Therefore, we proceed by estimating an unrestriced VAR(1) model for each country, whereby the variables, which were found to be non-stationary, are differenced.

As a kind of a robustness check, we also estimate the VAR models for shorter time-series samples (e.g. starting in 1998, due to above mentioned transformation period and possible structural break considerations), even though their results have to be treated with caution, as by doing so, we also lose considerable number of degrees of freedom. We find that the median projection and the range of the projections remain broadly unchanged for all the countries, except for the Czech Republic where a shorter sample raises the median projection by about five percentage points, possibly due to the sensitivity of the Czech model to the pronounced crisis period at the end of the sample. The detailed estimation tables for the chosen VAR models are shown in the Appendix (Tables A.2-A.5).

5 Projected Public Debt Paths and Risks to Debt Sustainability

In this section we put all the ingredients from Section 3 (endogenous fiscal policy) and Section 4 (description of the non-fiscal macroeconomic environment) together to generate by means of stochastic simulations a large sample of debt paths for a 5-year ahead forecasting horizon for the four Central and Eastern European countries under investigation (the Czech Republic, Hungary, Poland and Slovakia). Different debt paths are generated by two types of shocks: macro shocks (drawn from a joint distribution) stem from the VAR model and fiscal shocks from the estimated fiscal reaction function.

The subsequent fan charts summarize the frequency distribution of the projected debt paths and serve to illustrate the overall range of risks to the debt dynamics in our sample. Stepwise shaded areas capture different deciles of the frequency distribution. For instance, the darkest shaded area reflects debt paths located in the 5th and 6th decile of the distribution, thus representing a 20 percent confidence interval around the median projection. The overall colored cone, in turn, reflects the 2nd to 9th deciles of the distribution and depicts a confidence interval of 80 percent around the median projection.

For each country we experiment with five different scenarios, which basically correspond to different calibrations of the fiscal reaction function. In Figures 2-5, going from the upper left corner to the lower right one, we start with the baseline scenario, where the primary balance is calibrated in line with the favored FRF estimates (column (2) in Table 2). In the second scenario we only set the output gap coefficients $\hat{\gamma}_k$ in equation 4.1 to zero, i.e. we examine a situation where fiscal policy does not react to business cycle fluctuations (acyclical behavior). In a similar vein, in the third scenario we only set the coefficient for lagged debt $\hat{\rho}$ to zero. An increase in the primary balance is thus no longer the case when debt increases, i.e. we examine a situation where the government is not concerned about having debt under control. In contrast, in the fourth scenario we assume a coefficient for lagged debt which is twice as high as in the baseline ($\hat{\rho} = 0.1$). Finally, in the fifth scenario we replace in equation (4.1) the fit for the primary balance with the governments' yearly primary balance targets for 2012-2015 (for 2016 we assume the same value as in 2015), still allowing for unexpected, stochastic shocks, originating from the fiscal reaction function[6], i.e. $\widehat{pb}_{i,t+\tau} = SCP\ target_{i,t+\tau} + \varphi_{i,\,t+\tau}$. If available, also the planned stock-flow adjustments are included (based on the Stability and Convergence Programmes submitted to the European Commission in April 2012; for more details see Table 3). Uncertainty around the median debt projection is triggered in this scenario mainly by the macro shocks and not by systematic fiscal policy deviations. This scenario gives information about how effectively the defined targets contribute to the stabilization of debt levels until 2016.

Table 3 about here

Let us focus first of all on the preferred baseline scenario. When we draw our attention to the median projections solely, we cannot argue that public debt shows an explosive trend and is thus perceived to be sustainable over the period 2012-2016. However, when we also take the risks around the median projection into account, we get a more differentiated picture. The fiscal reaction function is apparently not responsive enough (with regard to public debt) to prevent increasing debt paths from covering a considerable share of the overall frequency distribution. For instance, in the Czech Republic the 2011 debt ratio (41.2%) is located in the 3rd decile of the 2016 distribution of projected debt paths; thus, there is at least a 70% (but not more than 75%) probability that the debt ratio increases from 2011 until 2016[7]. There is, however, only a small probability, of a bit more than 10%, that the debt ratio will surpass the 60%-threshold until 2016. Slovakia shares a very similar

[6] We still allow the residuals of the FRF to enter the debt-deficit stock-flow identity, i.e. the debt evolution is subject to stochastic fiscal shocks, which cannot be traced back to the variables that were included as regressors in equation (4). An example would be erratic policy actions or one-off events, such as natural disasters, that trigger an unexpected change in the primary balance.

[7] Figure A.1 in the Appendix illustrates (in line with Medeiros, 2012) for each country the empirical probabilities of exceeding a given debt value by 2016.

picture with the difference that the downside risks weigh a bit more strongly and the probability of having a debt ratio, which is larger in 2016 than in 2011 (43.3%), is about 60%. Hungary starts with a debt ratio of 80.6% in 2011 and will stay beyond 60% of GDP until 2016 with a probability of at least 80%. Although Hungary shows a decreasing median debt path (reaching 72.8% until 2016), there is a probability of at least 30% that the debt ratio increases from 2011 until the end of the forecasting horizon and could even reach more than 90% (with a probability of at least 10%). Poland shows a decreasing median projection as well (starting from 56.3% in 2011 and reaching 49.1% in 2016), whereby the upside risks are less pronounced than in Hungary. The probability that Poland surpasses the 60% debt-to-GDP threshold until 2016 is considerably small (at most 10%).

Next, let us confront the baseline scenario results with those of the alternative scenarios. A number of observations can be recorded. First, across all the four countries we can observe that the overall risks to future debt dynamics are larger (wider fan) in the baseline than in the SCP scenario. This indicates that a target-based fiscal policy behavior, which potentially limits systematic discretionary fiscal actions, helps to minimize risks to debt outcomes. The SCP scenario delivers in most countries also a smaller median projection than in the baseline. A notable exception is Slovakia, where the SCP target of a considerable primary deficit over 2012-15 (the other countries target on average a primary surplus, see Table 3) together with the planned stock-flow adjustments induce a higher median debt projection and the probability of surpassing the 60% threshold in 2016 increases to 30%. Second, the "no reaction to output gap"-scenario yields in all the four countries a higher median debt projection but also less uncertainty around it than in the baseline. This can be explained as follows: Taking the output gap coefficients of the FRF together, countercyclical fiscal policy dominates the baseline scenario. While countercyclical fiscal policy should produce approximately balanced fiscal outcomes over the cycle, this might not necessarily be the case in the situation of an acyclical fiscal policy, which could even have a bias towards a budget deficit both in times of a recession and a boom. As a result, it can indeed be the case that the debt dynamics are more buoyant with acyclical than with countercyclical fiscal policy. The lower uncertainty in this scenario can simply be explained by the fact that the fiscal policy response is the same no matter which business cycle situation the economy is confronted with. Third, the two debt scenarios illustrate that not being concerned about having debt under control leads to a clearly larger probability of exploding debt paths. In contrast, if countries put more weight on debt stabilization than in the baseline (e.g. to capture stronger-than-expected primary balance adjustments because of approaching constitutional debt limits), risks are clearly reduced and they can reduce their mean debt ratios rather quickly to moderate levels.

Figures 2-5 about here

Finally, when confronting our results with alternative methodologies for assessing debt sustainability, the best benchmark are the IMF's projections based on its deterministic DSA framework (regularly reported in the IMF's Art. IV staff reports). Figure 6 compares our baseline results with the respective IMF projections and shock scenarios. On the one hand, the IMF's baseline projections come until the end of the forecasting horizon very close to our median projection (except for Poland where it falls in the 7^{th} decile of the frequency distribution). On the other hand, our results confirm (in line with the discussion in Section 1) that the deterministic bound tests[8] do not fully capture the overall magnitude of risks identified by the SDSA approach. This holds especially for the combined shock scenario, which delivers a debt ratio in 2016 that falls in the Czech Republic and Slovakia within the 20% and in Hungary within the 40% confidence interval only. Even the IMF's growth shock scenario, which delivers the highest debt ratios in 2016 compared to other shocks to individual parameters, does not fully capture the SDSA-based dispersion of risks to future debt dynamics.

Figure 6 about here

6 Caveats Related to the SDSA Approach

Besides the abovementioned benefits, we also want to stress a few shortcomings of the SDSA approach, which offer room for further research and improvements. First, the SDSA framework still does not completely solve the problem with limited data availability for emerging markets. To a certain extent, this is dealt with by combining annual data in the FRF and the debt identity with quarterly data in the VAR model. However, both the FRF and the VAR are still relatively sensitive to model specification and the choice of variables. This might be overcome by trying to employ more robust models (e.g. by expanding the sample by additional emerging market economies), or including additional variables in the VAR which may help to explain the variation in the macroeconomic debt determinants. Theoretically, the VAR model could be replaced by any other econometric model which generates jointly estimated forecasts of the relevant macroeconomic variables. Therefore, the possibility of employing other models could be investigated, e.g. such as the OeNB's FORCEE forecasting model (see Crespo Cuaresma et al., 2009).

A second drawback of the SDSA approach is – even though there is interaction between the individual macroeconomic debt determinants and a reaction of fiscal policy to their development – the lack of feedback from fiscal policy to the macro environment (e.g. the risk premia as parts of the interest rates do not react to prudency or credibility of fiscal policy) in the framework. The SDSA approach shares this drawback with the traditional DSA.

Another possibly problematic issue is that in the SDSA macroeconomic and fiscal shocks are drawn from a joint normal distribution. This is only a broad approximation of the state of the world, because in reality, the shocks can be asymmetric or extreme events can occur more frequently under certain circumstances (e.g. in times of a crisis). Both of these features (asymmetry and fat tails) of macroeconomic shocks are not in line with the normality assumption of the frequency distribution. There have been attempts to address this problem with bootstrapping techniques to draw the shocks directly from their empirical distributions (Frank and Ley, 2009). However, deciding between using the simplifying normality assumption and using the empirical distribution, also means deciding between the relative simplicity and usability of the framework versus getting a more realistic shape of the fan chart and the risks it depicts. A possible compromise might be to use a more realistic

[8] Bound tests are stress tests to the baseline parameters. The growth shock scenario applies a permanent shock equal to one-half standard deviation (based on historical data) to the baseline projection of GDP growth. The combined shock scenario applies a one-quarter standard deviation shock to the interest rate, GDP growth and the primary balance (simultaneously).

distribution instead of the normal one, e.g. a distribution with fatter tails (such as the Student's t-distribution).

7 Summary and Concluding Remarks

In this paper we present an assessment to which extent public debt positions in four CESEE economies (Czech Republic, Hungary, Poland and Slovakia) are sustainable in the medium term. For this purpose we employ a stochastic debt sustainability analysis (SDSA), which allows us to project a distribution of debt paths until 2016 under jointly determined shock configurations. The resulting median projections together with a confidence interval around them (depicted in the fan charts) illustrate the risks associated with the projected debt paths.

A number of results flow from this setting. First of all, let us turn to the estimated fiscal reaction function, which is not the core part of the sustainability assessment, but a necessary step to come up with a characterization of the responsiveness of fiscal policy to debt dynamics. The primary balance in the CESEE countries under consideration exhibits a great deal of persistence and responds in a corrective manner to increasing public debt and in a countercyclical manner to business cycle fluctuations (in line with Staehr, 2007). Nevertheless, the results cannot be traced back to discretionary policy measures or the functioning of automatic stabilizers, as we only use the headline primary balance, not the cyclically adjusted one. Therefore, it might still be the case that discretionary fiscal policy acts procyclically (as found e.g. by Eller, 2009).

Moving on to the question in the paper's title, we arrive at the following answers: When drawing our attention to the median projections solely, we cannot argue that public debt in the four CESEE countries shows an explosive trend. Therefore, public debt can be perceived as being sustainable over the period 2012-2016. However, the achievement of the median debt path is still subject to notable risks, which should be taken into account by the decision makers when formulating policy. The Czech Republic and Slovakia show the highest probability of an increasing debt ratio from 2011 until 2016 (but still somewhat below the 75% threshold of Ferrucci and Penalver, 2003). Moreover, as can be seen when comparing Hungary, which has a relatively high debt ratio, to the other three countries, the uncertainty is larger when the existing debt stock is comparatively high. Therefore, not addressing the debt-increasing risks today might lead to even more uncertainty and possible higher debt volatility in the future.

Our results confirm that the compliance with the SCP targets (even when they are comparatively less ambitious), helps to limit the overall risks to the debt outturns and reduces debt ratios in most countries. We also find that an acyclical fiscal policy (i.e. a policy which does not react to business cycle fluctuations) has a similar effect in that it reduces uncertainty, but, nevertheless, it leads to somewhat larger central debt projections than in the baseline. This may be due to some deficit bias, as highlighted by the persistence of the (negative) primary balance in the FRF, which is present irrespective of the business cycle.

Several sensitivity assessments show that a policy that does not take debt developments into account leads to a clearly larger probability of exploding debt paths. In contrast, if countries put more weight on debt stabilization than in the past, risks are clearly reduced and their mean debt ratios can be squeezed rather quickly to moderate levels.

Comparing our results with the results of the traditional DSA approach of the IMF, it becomes apparent that the baseline central debt projections do not differ significantly. However, the plausibility of the traditional approach suffers from the fact that there is no interaction among the macroeconomic determinants being shocked in each stress test. This drawback can be overcome by utilizing the chosen stochastic approach which provides a wider, but more realistic, probability distribution of future debt realizations.

To sum up, the SDSA approach provides a clear value added when used for the assessment of public debt sustainability in economies with considerable economic volatilities. The probability distribution of future debt outturns captures interactions among the macroeconomic and fiscal variables being shocked, informs about the plausible range of risks associated with the projected debt paths and thus prepares policymakers for a better-informed policy reaction should these risks materialize.

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Table 1: The Evolution of General Government Budget Balances and Debt

(in % of GDP)

Country	Year											
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
The Czech Republic												
Headline Balance	-3.6	-5.6	-6.5	-6.7	-2.8	-3.2	-2.4	-0.7	-2.2	-5.8	-4.8	-3.1
Primary Balance	-2.8	-4.6	-5.4	-5.6	-1.7	-2.1	-1.3	0.4	-1.1	-4.5	-3.4	-1.7
Public Debt	17.8	23.9	27.1	28.6	28.9	28.4	28.3	27.9	28.7	34.4	38.1	41.2
Hungary												
Headline Balance	-3.0	-4.1	-9.0	-7.3	-6.5	-7.9	-9.4	-5.1	-3.7	-4.6	-4.2	4.3
Primary Balance	2.3	0.6	-4.9	-3.2	-2.1	-3.8	-5.5	-0.9	0.5	0.1	-0.1	8.4
Public Debt	56.1	52.7	55.9	58.6	59.5	61.7	65.9	67.1	73.0	79.8	81.4	80.6
Poland												
Headline Balance	-3.0	-5.3	-5.0	-6.2	-5.4	-4.1	-3.6	-1.9	-3.7	-7.4	-7.8	-5.1
Primary Balance	0.0	-2.2	-2.1	-3.2	-2.6	-1.3	-0.9	0.4	-1.5	-4.8	-5.1	-2.4
Public Debt	36.8	37.6	42.2	47.1	45.7	47.1	47.7	45.0	47.1	50.9	54.8	56.3
Slovakia												
Headline Balance	-12.3	-6.5	-8.2	-2.8	-2.4	-2.8	-3.2	-1.8	-2.1	-8.0	-7.7	-4.8
Primary Balance	-8.2	-2.5	-4.6	-0.3	-0.2	-1.1	-1.7	-0.4	-0.9	-6.6	-6.4	-3.2
Public Debt	50.3	48.9	43.4	42.4	41.5	34.2	30.5	29.6	27.9	35.6	41.1	43.3

Source: Eurostat

Table 2: Estimates of the Fiscal Reaction Function

Dependent variable: primary balance as % of GDP	(1) Pooled OLS	(2) Fixed Effects **baseline**	(3) Fixed Effects	(4) Fixed Effects	(5) Fixed Effects	(6) Fixed Effects	(7) Fixed Effects	(8) Fixed Effects	(9) Fixed Effects year dummies	(10) System GMM
First lag primary balance ratio	0.498***	0.301***	0.257***	0.375***	0.315***	0.297***	0.300***	0.302***	0.285**	0.626***
	[0.083]	[0.045]	[0.072]	[0.067]	[0.064]	[0.049]	[0.049]	[0.043]	[0.098]	[0.092]
Second lag primary balance ratio										0.038
										[0.097]
First lag debt ratio	0.026**	0.053**	0.059**	0.037*	0.051**	0.055**	0.060	0.027	0.056***	0.033
	[0.012]	[0.020]	[0.020]	[0.016]	[0.016]	[0.021]	[0.040]	[0.069]	[0.015]	[0.033]
Lagged debt spline (40%)							-0.011			
							[0.082]			
Lagged squared debt ratio								0.000		
								[0.001]		
Output gap (Hodrick-Prescott)	0.295***	0.322**					0.324**	0.318**	0.043	0.350**
	[0.095]	[0.097]					[0.107]	[0.105]	[0.300]	[0.109]
First lag OG (HP)	-0.247***	-0.156*					-0.150**	-0.165**	-0.082	-0.350*
	[0.091]	[0.080]					[0.051]	[0.059]	[0.129]	[0.179]
Output gap (trend-based)			0.259**							
			[0.086]							
First lag OG (trend)			-0.154*							
			[0.073]							
Output gap (potential GDP)				0.308**						
				[0.107]						
First lag OG (potential)				-0.220**						
				[0.069]						
Absolute value of OG (trend)					0.244**					
					[0.089]					
First lag of absolute OG (trend)					-0.209**					
					[0.065]					
Positive OG (HP)						0.486*				
						[0.211]				
First lag of positive OG (HP)						-0.234*				
						[0.103]				
Negative OG (HP)						-0.003				
						[0.176]				
First lag of negative OG (HP)						-0.094				
						[0.226]				
CPI-inflation	0.047*	0.083*	0.110**	0.076**	0.080	0.082*	0.084*	0.081*	0.089	-0.000
	[0.025]	[0.040]	[0.042]	[0.026]	[0.042]	[0.040]	[0.037]	[0.034]	[0.052]	[0.027]
Crisis dummy	-0.889**	-1.089*	-0.934	-0.575	-0.967*	-1.235**	-1.087*	-1.106**		-0.916**
	[0.346]	[0.489]	[0.524]	[0.455]	[0.482]	[0.411]	[0.501]	[0.464]		[0.337]
Constant	-1.841***	-3.305**	-3.829***	-2.770***	-3.299**	-3.562**	-3.489**	-2.796*	-5.132***	-1.590
	[0.578]	[0.987]	[0.961]	[0.665]	[0.989]	[1.218]	[1.175]	[1.222]	[0.832]	[1.661]
Observations	116	116	116	99	116	116	116	116	116	108
R-squared	0.556	0.501	0.509	0.561	0.481	0.512	0.501	0.502	0.575	
Adjusted R-squared	0.531									
Number of id		8	8	7	8	8	8	8	8	8
Overall R-squared		0.503	0.485	0.598	0.496	0.508	0.498	0.512	0.541	
Fp										0.000
Hansenp										1
ar1p										0.0378
ar2p										0.570
No of collapsed instruments										15

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

Table 3: Target primary balances of individual countries for 2012-2015 used in the "Stability and Convergence Program Targets Scenario"

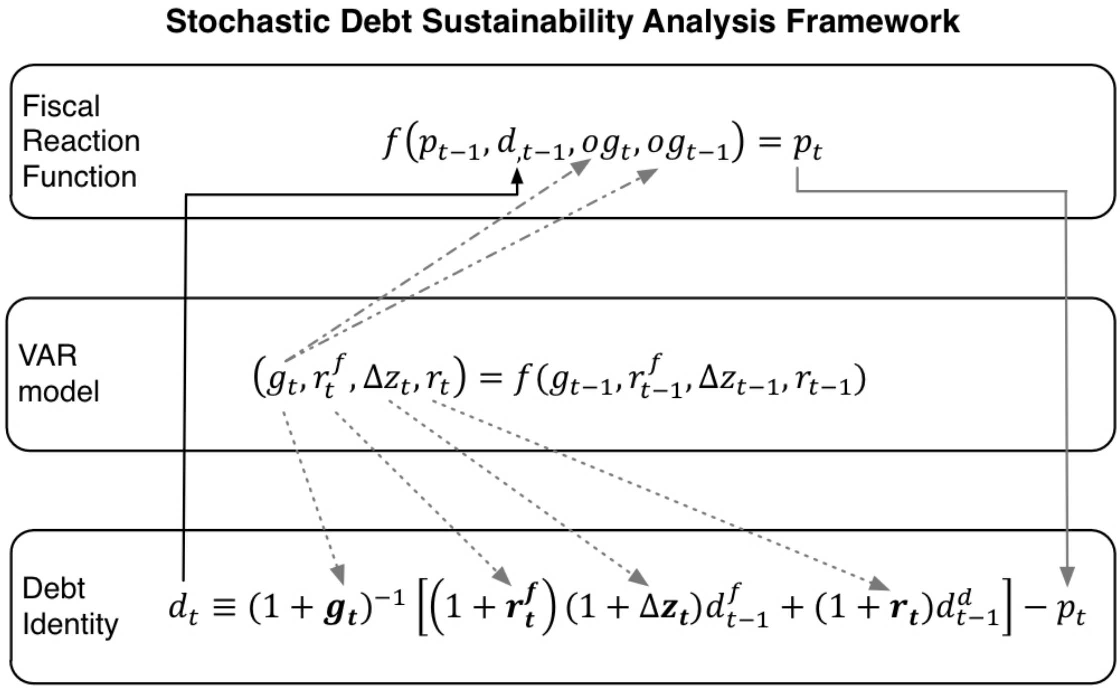
(% of GDP)

Country	Year				
	2012	**2013**	**2014**	**2015**	**Average**
The Czech Republic					
Target primary balance	-1.5	-1.3	-0.1	0.8	-0.5
Planned stock-flow adjustment (SFA)*	0.7	-0.7	-0.5	-0.5	-0.3
Primary balance adjusted for the SFA	-2.2	-0.6	0.4	1.3	-0.3
Hungary					
Target primary balance	1.6	2.0	2.2	2.2	2.0
Planned stock-flow adjustment (SFA)*	-	-	-	-	-
Primary balance adjusted for the SFA	1.6	2.0	2.2	2.2	2.0
Poland					
Target primary balance	-0.2	0.5	1.0	1.6	0.7
Planned stock-flow adjustment (SFA)*	-	-	-	-	-
Primary balance adjusted for the SFA	-0.2	0.5	1.0	1.6	0.7
Slovakia					
Target primary balance	-2.9	-2.5	-2.1	-1.5	-2.3
Planned stock-flow adjustment (SFA)*	3.6	1.3	1.6	0.6	1.8
Primary balance adjusted for the SFA	-6.5	-3.8	-3.7	-2.1	-4.0

*Note: *only stock-flow adjustment that does not include revaluation effects due to exchange rate movements is included here, as the exchange rate revaluation effects are already included in the debt simulations. For Hungary and Poland, no detailed information about what fraction of SFA is due to exchange rate movements was available in the Stability and Convergence Programmes, therefore we did not include the SFA in our primary balance calculations for these countries.*

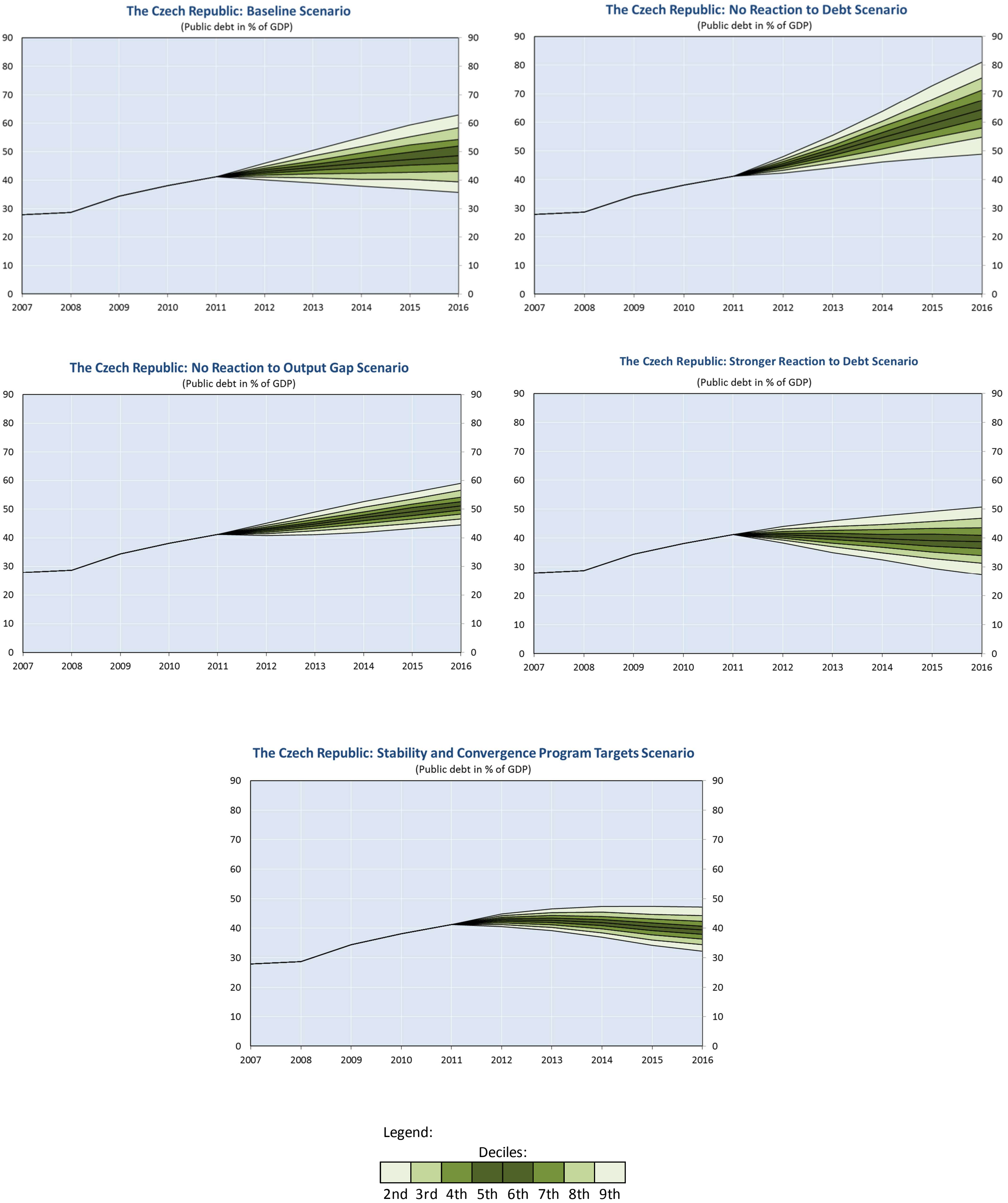
Source: Stability and Convergence Programmes 2012, Commission Staff Working Documents - Assessment of the 2012 National Reform Rrogrammes and Stability Programmes 2012.

Figure 1: Building Blocks of the Stochastic Debt Sustainability Analysis Framework



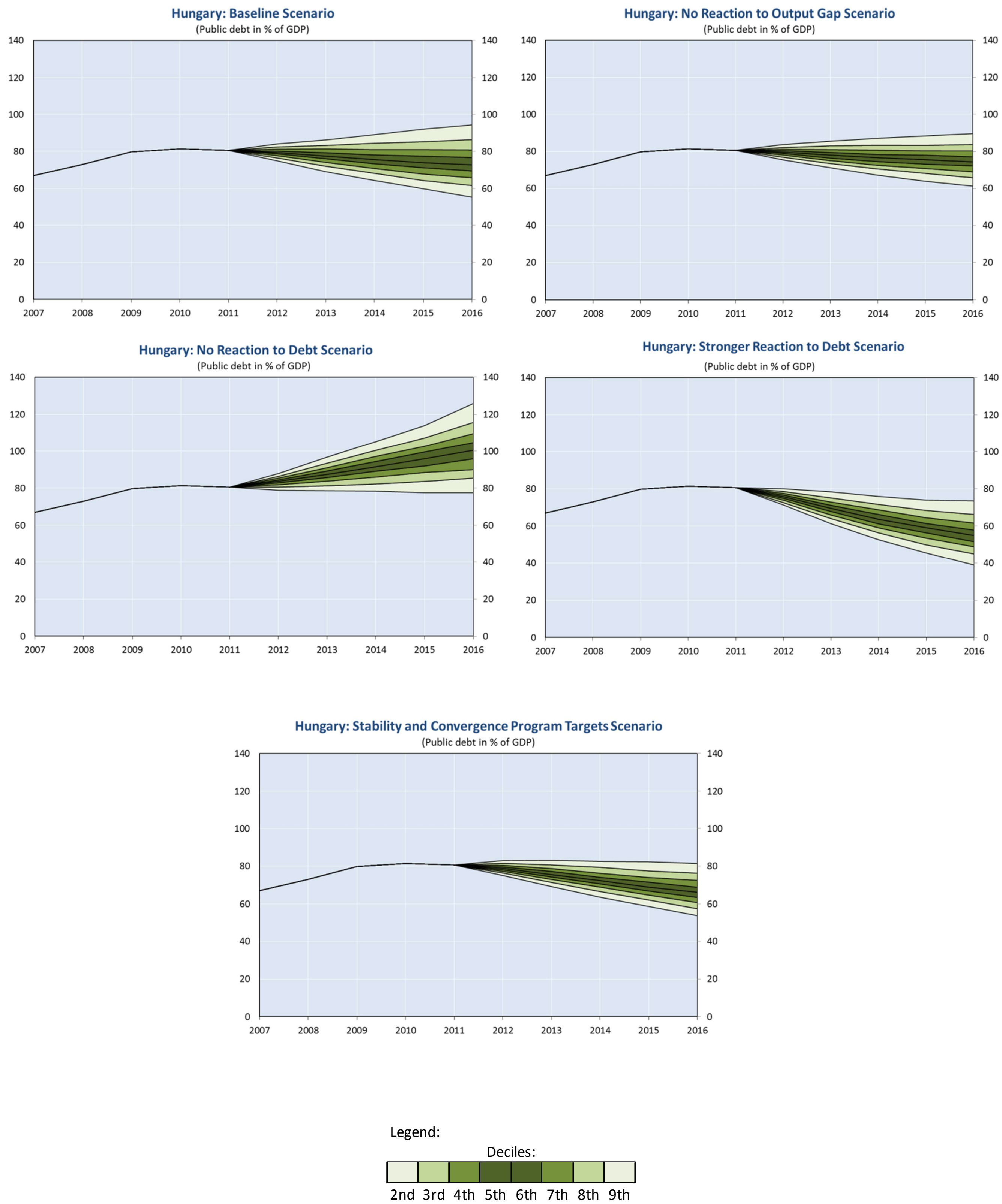
Note: p – primary balance (% of GDP), d –debt (% of GDP), d^f – foreign-currency debt (% of GDP), d^d – domestic-currency debt (% of GDP), og – output gap (% of potential GDP), g – GDP growth yoy (%), r^f – real foreign interest rate (%), r – real domestic interest rate, Δz – exchange rate depreciation (% yoy), t – time subscript
Source: Celasun, Debrun, Ostry (2007), authors

The Czech Republic Fan Charts



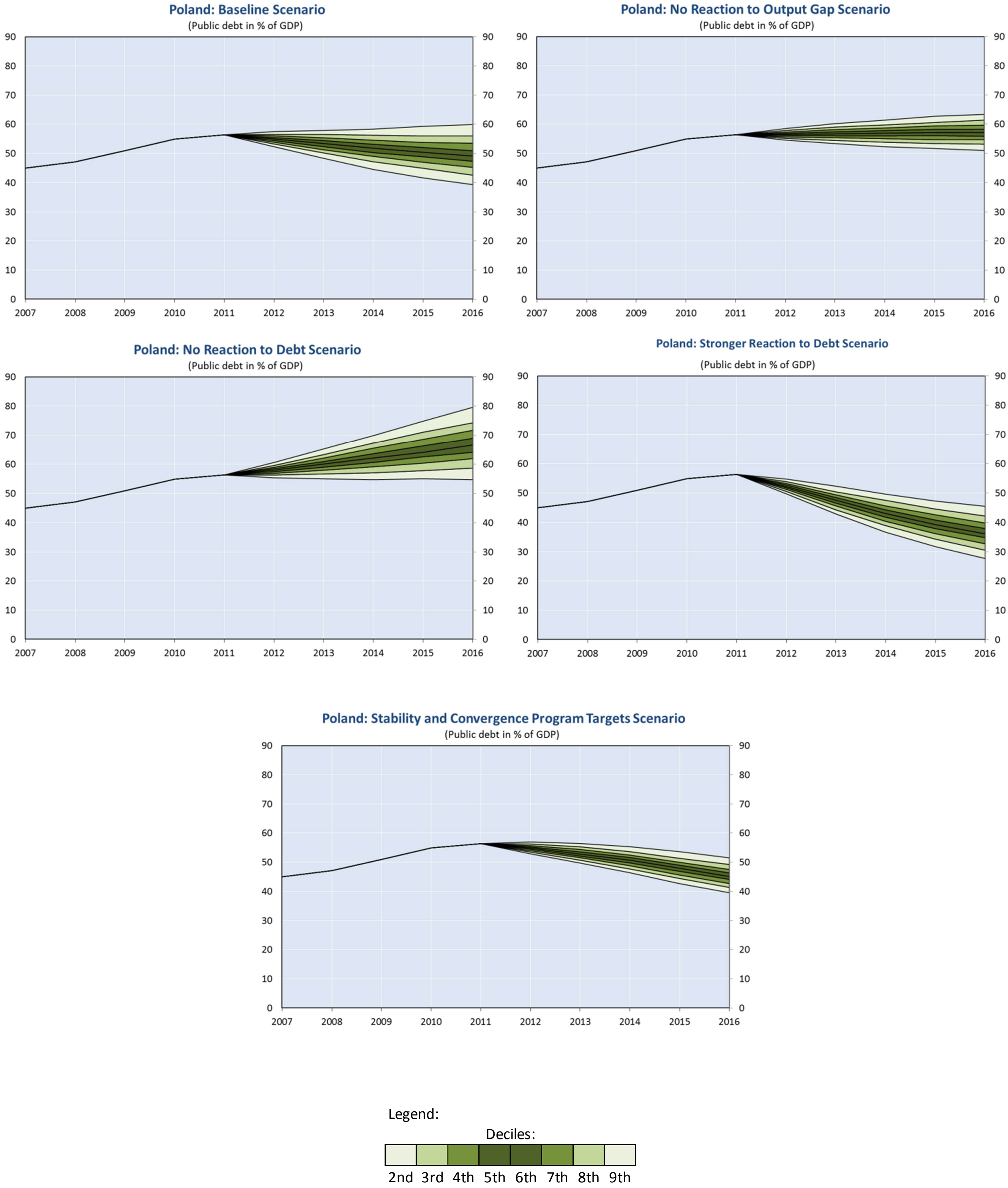
Source: Eurostat, authors's calculations

Hungary Fan Charts



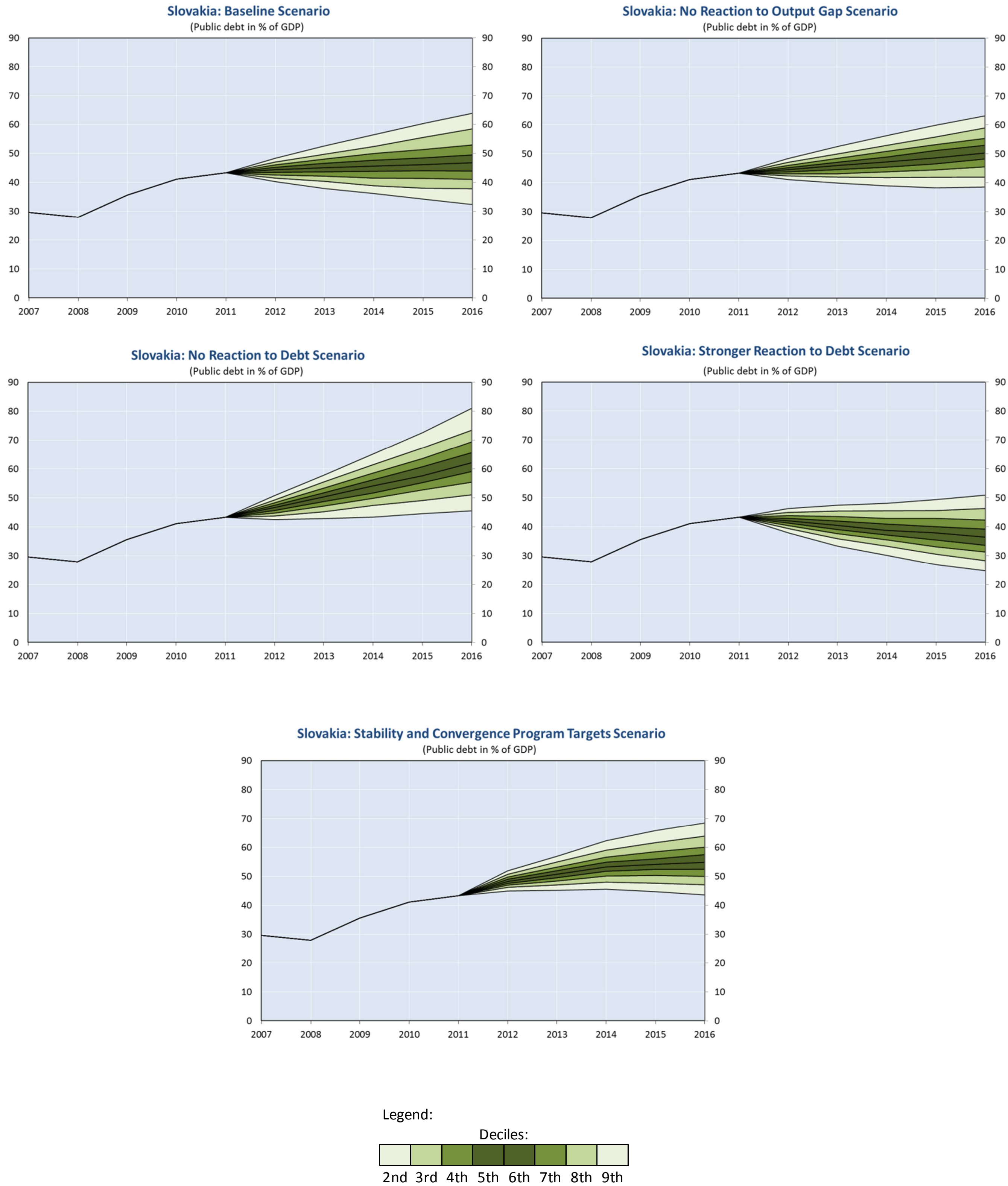
Source: Eurostat, authors' calculations

Poland Fan Charts



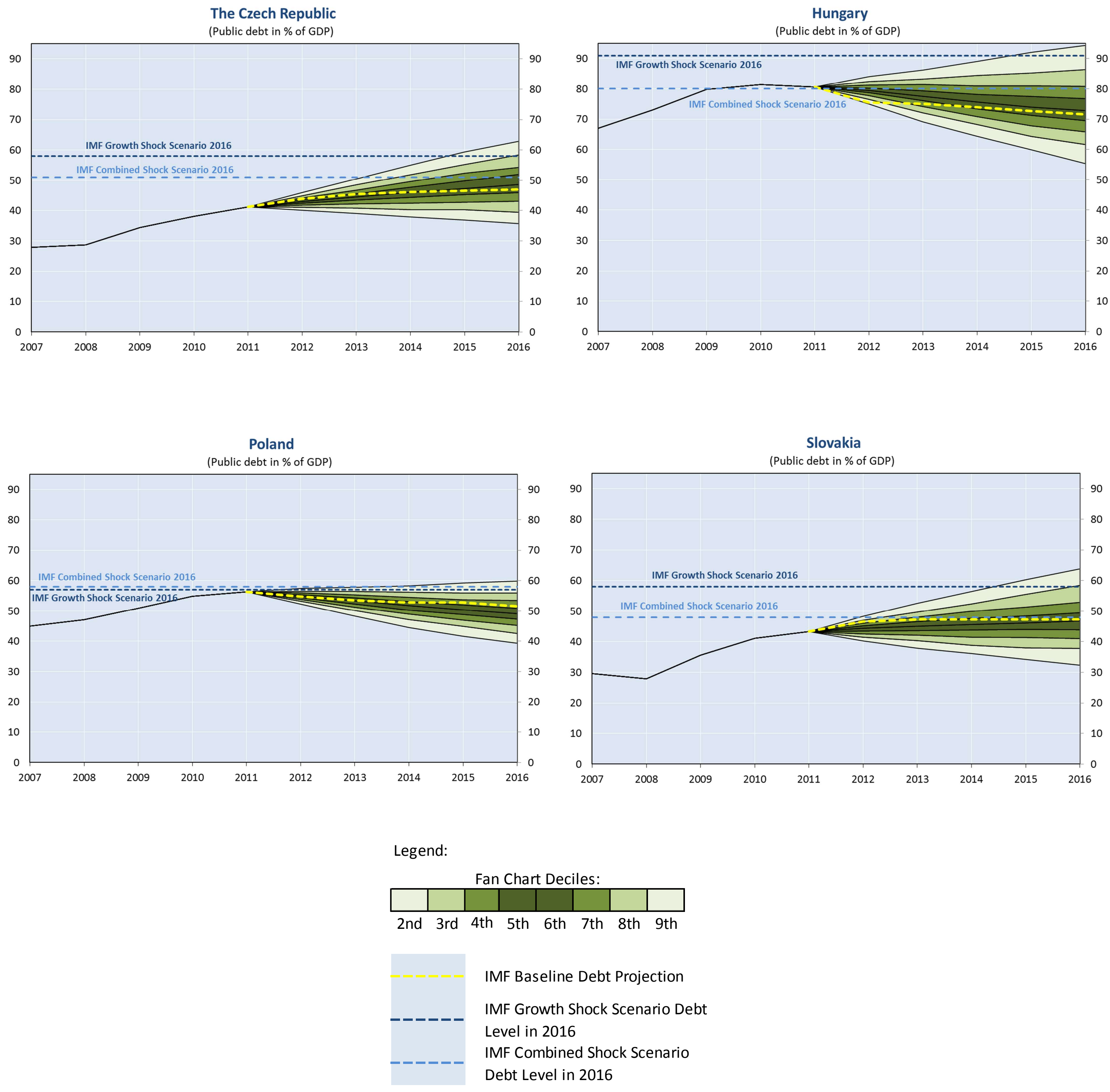
Source: Eurostat, authors' calculations

Slovakia Fan Charts



Source: Eurostat, authors' calculations

Comparison of the Baseline Projections with the IMF Projections



Source: IMF, authors's calculations

Appendix

Table A1: Annual variables used in the estimation of the Fiscal Reaction Function

Variable	Code	Description	Unit (range)	Source
General government primary balance	pbal	General government net lending/borrowing excluding interest (EDP definition)	% of GDP	Eurostat, Ameco for Croatia
General government consolidated gross debt	debt	General government consolidated gross debt (EDP definition)	% of GDP	Eurostat, Ameco for Croatia
Output gap (deviation from trend)	OG_trend	Deviation of actual real GDP from a HP-filter trend	% of trend GDP	Ameco; authors' calculations for Croatia
Output gap (deviation from potential)	OG_potential	Deviation of actual real GDP from potential output based on a production function (European Commission approach)	% of potential GDP	Ameco; not available for Croatia
Real GDP	gdp	GDP at 2005 market prices (chain-linked values)	ions of local currency u	Eurostat; IMF for Romania
Real GDP year-on-year growth	gdp_growth	Year-on-year growth of GDP at 2005 market prices (chain-linked values)	%	Eurostat; IMF for Romania
Output growth differential vis-à-vis Germany	growth_dif	Difference between annual real GDP growth in the respective county and in Germany	percentage points	Eurostat, IMF for Romania; authors' calculations
HICP inflation	hicp	All-items harmonized index of consumer prices (2005=100), average annual change	%	Eurostat
GDP deflator	deflator	Annual change of implicit price deflator index based on GDP 2005 chain linked values	%	Eurostat
CPI inflation	cpi	Annual change of the nationally defined consumer price index	%	wiiw
Trade openness	open	Sum of the shares of exports and imports on GDP	% of GDP	Eurostat; authors' calculations
TI Corruption perception index	transp	Transparency International Corruption perception index	uption] to 10 [no corrup	Transparency International Corruption perception index annual reports
WB Governance index	govern	simple average of all six World Bank Governance indicators	ıance] to +2.5 [strong g	World Bank
EC Fiscal rules index	fri	European Commission Fiscal Rules Index; higher values indicate "better" fiscal rules	across EU27 and 1990-2010 takes values from -1.02 to +2.32	European Commission
Elections indicator variable1	elec1	Variable takes on value 1 in the election year and 0 otherwise	{0,1}	Comparative political data set III. (http://www.ipw.unibe.ch/content/team/klaus_armingeon/comparative_political_data_sets/index_ger.html), http://psephos.adam-carr.net, http://www.parties-and-elections.de/
Elections indicator variable2	elec2	In the election year, the variable takes on value of fraction of 1, corresponding to the fraction of the year preceding the elections; 0 otherwise. E.g. for elections in March 1997, the variable takes on value 0.25 in 1997 and 0 otherwise.	[0,1]	Comparative political data set III. (http://www.ipw.unibe.ch/content/team/klaus_armingeon/comparative_political_data_sets/index_ger.html), http://psephos.adam-carr.net, http://www.parties-and-elections.de/
Elections indicator variable3	elec3	In the election year, the variable takes on value of fraction of 1, corresponding to the fraction of the year preceding the elections, in the pre-election year, the variable takes on value of the remaining fraction of 1; 0 otherwise. Eg. For election in March 1997, the variable takes on value 0.25 in 1997 and 0.75 in 1996 and 0 otherwise.	[0,1]	Comparative political data set III. (http://www.ipw.unibe.ch/content/team/klaus_armingeon/comparative_political_data_sets/index_ger.html), http://psephos.adam-carr.net, http://www.parties-and-elections.de/
Elections indicator variable4	elec4	Variable takes on value 1 in the election year and 0 otherwise; early elections are not included.	{0,1}	Comparative political data set III. (http://www.ipw.unibe.ch/content/team/klaus_armingeon/comparative_political_data_sets/index_ger.html), http://psephos.adam-carr.net, http://www.parties-and-elections.de/
Elections indicator variable5	elec5	In the election year, the variable takes on value of fraction of 1, corresponding to the fraction of the year preceding the elections; 0 otherwise. Early elections are not included. E.g. for elections in March 1997, the variable takes on value 0.25 in 1997 and 0 otherwise.	[0,1]	Comparative political data set III. (http://www.ipw.unibe.ch/content/team/klaus_armingeon/comparative_political_data_sets/index_ger.html), http://psephos.adam-carr.net, http://www.parties-and-elections.de/
Elections indicator variable6	elec6	In the election year, the variable takes on value of fraction of 1, corresponding to the fraction of the year preceding the elections, in the pre-election year, the variable takes on value of the remaining fraction of 1; 0 otherwise. Early elections are not included.Eg. For election in March 1997, the variable takes on value 0.25 in 1997 and 0.75 in 1996 and 0 otherwise.	[0,1]	Comparative political data set III. (http://www.ipw.unibe.ch/content/team/klaus_armingeon/comparative_political_data_sets/index_ger.html), http://psephos.adam-carr.net, http://www.parties-and-elections.de/
IMF program indicator variable	imf	Variable taking on the value 1 if the country took part in any IMF program in the given year; 0 otherwise	{0,1}	International Monetary Fund, History of lending arrangements by country

Table A2: Quarterly Variables Used in the VAR Models

Variable	Code	Description	Unit (range)	Source
Real foreign interest rate	de_rir	German nominal long-term government bond yield (p.a.) adjusted for CPI inflation	% p.a.	Eurostat, IMF (CPI)
Real domestic interest rate	roxir	Domestic nominal long-term government bond yield (p.a.) adjusted for CPI inflation	% p.a.	Oxford Economics (Note: Oxford Economics data was used due to the best -longest- availability, this data is almost perfectly correlated to Eurostat long-term government bond yield series, where available), wiiw (CPI)
Real GDP growth rate	growth	Year-on-year growth of GDP at 2005 market prices (chain-linked values)	percentage points	Eurostat
Real effective exchange rate	dlreer	Real effective exchange rate (CPI deflated)	difference of the log of index (2005=100)	IMF IFS

Table A.2: The Czech Republic VAR Coefficients

	Difference of Foreign Interest rate	Domestic Interest Rate	Growth	dlogREER
Difference of Foreign Interest Rate (-1)	-0.147159 -0.12501 [-1.17719]	0.535315 -0.31386 [1.70561]	-0.477908 -0.52496 [-0.91038]	-0.142243 -0.63847 [-0.22279]
Domestic Interest Rate (-1)	-0.062284 -0.03457 [-1.80190]	0.842705 -0.08678 [9.71039]	-0.084218 -0.14516 [-0.58020]	-0.316316 -0.17654 [-1.79173]
Growth (-1)	-0.007618 -0.01894 [-0.40229]	-0.003769 -0.04755 [-0.07927]	0.700997 -0.07952 [8.81482]	-0.023089 -0.09672 [-0.23872]
dlogREER (-1)	-0.027364 -0.02483 [-1.10207]	0.094434 -0.06234 [1.51484]	0.141486 -0.10427 [1.35694]	0.259586 -0.12682 [2.04696]
Constant	0.001266 -0.00156 [0.81091]	0.003785 -0.00392 [0.96583]	0.008709 -0.00655 [1.32867]	0.015763 -0.00797 [1.97730]
Adj. R-squared	0.022444	0.64645	0.62749	0.093744

Residuals correlation matrix:

	Difference of Foreign interest rate	Domestic Interest Rate	Growth	dlogREER
Difference of Foreign Interest Rate	1.000	0.335	-0.220	0.152
Domestic Interest Rate	0.335	1.000	-0.219	-0.026
Growth	-0.220	-0.219	1.000	0.022
dlogREER	0.152	-0.026	0.022	1.000

Note: Standard errors in ( ) & t-statistics in [ ]
Source: authors' calculations

Table A.3: Hungary VAR Coefficients

	Difference of Foreign Interest Rate	Difference of Domestic Interest Rate	Growth	dlogREER
	-0.180717	-0.122586	-0.610371	-0.832724
Difference of Foreign Interest Rate (-1)	-0.13045	-0.30072	-0.33343	-0.81699
	[-1.38535]	[-0.40764]	[-1.83058]	[-1.01925]
	0.04247	0.255407	-0.103082	-0.506245
Difference of Domestic Interest Rate (-1)	-0.05632	-0.12983	-0.14396	-0.35273
	[0.75407]	[1.96717]	[-0.71606]	[-1.43521]
	0.020508	0.065493	0.883186	-0.026287
Growth (-1)	-0.02236	-0.05154	-0.05715	-0.14003
	[0.91720]	[1.27063]	[15.4538]	[-0.18772]
	0.002594	0.090394	0.077776	0.231541
dlogREER (-1)	-0.0225	-0.05188	-0.05752	-0.14095
	[0.11528]	[1.74238]	[1.35210]	[1.64276]
	-0.001538	-0.001072	0.002148	0.0049
Constant	-0.00086	-0.00199	-0.0022	-0.0054
	[-1.78289]	[-0.53922]	[0.97403]	[0.90697]
Adj. R-squared	-0.014116	0.052853	0.797572	0.07046

Residuals correlation matrix:

	Difference of Foreign Interest Rate	Difference of Domestic Interest Rate	Growth	dlogREER
Difference of Foreign Interest Rate	1.000	0.138	-0.238	0.075
Difference of Domestic Interest Rate	0.138	1.000	-0.178	-0.326
Growth	-0.238	-0.178	1.000	0.102
dlogREER	0.075	-0.326	0.102	1.000

Note: Standard errors in ( ) & t-statistics in [ ]

Source: authors' calculations

Table A.4: Poland VAR Coefficients

	Difference of Foreign Interest rate	Domestic Interest Rate	Growth	dlogREER
Difference of Foreign Interest Rate (-1)	-0.153721	-0.223574	-0.187842	-2.986906
	-0.131	-0.25251	-0.44152	-1.0359
	[-1.17340]	[-0.88540]	[-0.42544]	[-2.88339]
Domestic Interest Rate (-1)	-0.013856	0.805783	-0.078772	-0.145797
	-0.03861	-0.07442	-0.13013	-0.30531
	[-0.35886]	[10.8273]	[-0.60535]	[-0.47754]
Growth (-1)	-0.022354	-0.103208	0.59626	0.308837
	-0.03242	-0.06249	-0.10927	-0.25638
	[-0.68945]	[-1.65147]	[5.45660]	[1.20461]
dlogREER (-1)	0.00816	0.072123	0.028389	0.180419
	-0.01544	-0.02976	-0.05204	-0.1221
	[0.52848]	[2.42322]	[0.54550]	[1.47763]
Constant	0.000466	0.010544	0.019512	-0.009202
	-0.00237	-0.00457	-0.008	-0.01877
	[0.19616]	[2.30486]	[2.43937]	[-0.49036]
Adj. R-squared	-0.028956	0.720959	0.388978	0.138347

Residuals correlation matrix:

	Difference of Foreign Interest rate	Domestic Interest Rate	Growth	dlogREER
Difference of Foreign Interest rate	1.000	0.211	0.142	0.023
Domestic Interest Rate	0.211	1.000	-0.190	0.028
Growth	0.142	-0.190	1.000	0.016
dlogREER	0.023	0.028	0.016	1.000

Note: Standard errors in ( ) & t-statistics in [ ]
Source: authors' calculations

Table A.5: Slovakia VAR Coefficients

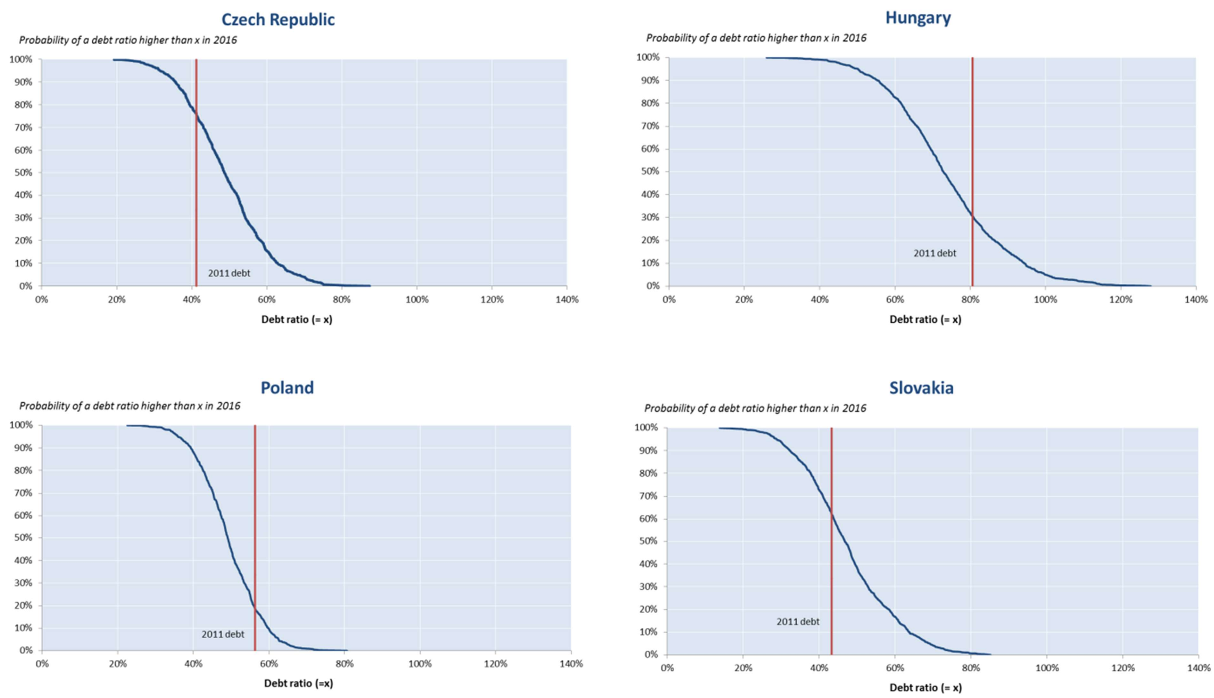
	Difference of Foreign Interest rate	Domestic Interest Rate	Growth	dlogREER
	-0.188932	1.085334	-0.546397	0.046724
Difference of Foreign Interest Rate (-1)	-0.12485	-0.53113	-0.78888	-0.55065
	[-1.51324]	[2.04346]	[-0.69263]	[0.08485]
	0.00447	0.915103	-0.080874	-0.084722
Domestic Interest Rate (-1)	-0.01212	-0.05154	-0.07656	-0.05344
	[0.36891]	[17.7538]	[-1.05637]	[-1.58540]
	0.000906	0.066188	0.629364	0.130699
Growth (-1)	-0.01517	-0.06452	-0.09583	-0.06689
	[0.05974]	[1.02587]	[6.56756]	[1.95393]
	0.054953	0.03741	-0.152167	0.219558
dlogREER (-1)	-0.02785	-0.11848	-0.17597	-0.12283
	[1.97315]	[0.31576]	[-0.86473]	[1.78749]
	-0.001816	0.000545	0.019505	0.005434
Constant	-0.00108	-0.0046	-0.00683	-0.00477
	[-1.68007]	[0.11862]	[2.85672]	[1.14014]
Adj. R-squared	0.023956	0.837983	0.405698	0.105722

Residuals correlation matrix:

	Difference of Foreign Interest rate	Domestic Interest Rate	Growth	dlogREER
Difference of Foreign Interest rate	1.000	-0.008	-0.185	0.086
Domestic Interest Rate	-0.008	1.000	0.228	-0.181
Growth	-0.185	0.228	1.000	-0.268
dlogREER	0.086	-0.181	-0.268	1.000

Note: Standard errors in ( ) & t-statistics in [ ]
Source: authors' calculations

Empirical probability of exceeding a given debt value by 2016



Source: Eurostat, authors' calculations