The Checks of Czechs: Optimizing the Debt Portfolio of the Czech Government

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Abstract

Sound debt management practices help protect government expenditures on debt servicing from aggregate shocks and prevent the occurrence of debt crises. Building on Giavazzi and Missale (2004), this article examines the optimal allocation of government debt for the Czech Republic. To calibrate conditional expectations of macro variables and to identify unexpected shocks, a vector autoregression (VAR) model for the Czech macroeconomy is estimated. The estimated optimal allocations across short-term debt, inflation-linked debt, long-term debt, and foreign currency debt are then discussed in relation to the actual allocations implemented by the government debt managers in the Czech Republic. We find that the manager of Czech government's debt allocates too much debt into short-term bills and too little debt into inflation-linked bonds based on the estimated optimal allocations. Deepening the market for inflation-linked bonds and improving government cash management are the core policy recommendations.

Key words: Public debt management; Optimal debt allocation; VAR model; Czech Republic, Emerging Market Economies.

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1. Introduction

A government's debt portfolio contains complex financial structures and can create substantial balance sheet risk for the government or cash flow risk for the state budget. Sound debt management practices can help prevent the occurrence of debt crises, reduce vulnerability of government finances to macroeconomic and financial shocks, and support economic growth. The IMF and the World Bank therefore published, in cooperation with national debt management experts, a set of guidelines on public debt management for policy makers (IMF and WB, 2001). This work includes formulation and properties of public debt management objectives, the underlying institutional framework and possible coordination challenges, formulation of the debt management strategy, attributes of a sound risk management framework, and other important areas of public debt management.

Much has been written about public debt management and the strategies for optimal debt allocation (Sargent and Wallace 1981; Bohn 1990, 1998; Missale 1997; and Missale and Blanchard 1991, among others). Also, the recent financial and public debt crises have demonstrated the important role of public debt management strategy and debt allocation for economic growth. From a practical standpoint, Melecky (2012a) reviews debt management strategies around the world and studies possible drivers behind the varying formulations of public debt management strategies. Hawkesby and Wright (1997) adapt a tax-smoothing methodology used in Bohn (1990) and impose realistic constrains to public debt management to conduct debt allocation analysis for nine OECD countries. Buera and Nicolini (2002) find that the size of financial transactions that the government must undertake each period to replicate state contingent bonds is very large and increases dramatically with the number of states. Gerard and Gilson (2001) show, in a simple two country model, how an exchange rate regime can influence the public debt structure. Because the exchange rate risk is historically the most important risk for debt managers in emerging market economies, Melecky (2012b) provides a review of policy approaches to choosing the currency structure of foreign-currency debt. In addition, Melecky (2010) develops a practical approach that debt managers can use when deciding on the currency allocation of public external debt across multiple foreign currencies based on synchronization indicators of exchange rate volatility.

This paper focuses on public debt management in the Czech Republic, because its experience, of progressing from a transition economy to an emerging market and a high-income economy could be informative for debt managers and policy makers in developing and emerging market economies. Although numerous studies have focused on fiscal discipline and debt sustainability issues (Bulir 2004; Melecky A. and Melecky M. 2012, EC 2012; IMF 2013; Dybczak and Melecky 2014), only Matalík and Slavík (2005) to our knowledge focused explicitly on applied government debt management in the Czech Republic. They argue that government debt management in the Czech Republic went through dynamic development during the transition period of the 1990s and early 2000s. A very low initial level of government debt, missing fundamental segments of the financial market, and the absence of basic debt instruments, combined with small or non-existent fiscal deficits, impeded development of the domestic debt market in the Czech Republic. The need to establish a functioning government bond market to spur domestic capital market development and manage risk from foreign currency exposures, thus arose. Matalík and Slavík (2005) recommend that public debt management be included as part of the state treasury management functions. This recommendation contradicts that of Wheeler (2004) who argues for some independence of the debt management function.

This paper focuses specifically on the allocation strategy for government debt in the Czech Republic. It builds on the theoretical approach of Giavazzi and Missale (2004) to empirically analyze the optimal government debt allocation for the Czech Republic. The identification of unexpected shocks in this approach draws on conditional expectations from an estimated VAR model for the Czech macroeconomy. Moreover, the paper discusses the estimated optimal allocation shares in relation to the actual ones implemented by the government debt managers in the Czech Republic. It also studies the robustness of the determined optimal debt allocation using a sensitivity analysis. Based on the conducted analysis the paper aims to propose implementable policy recommendations to improve the debt management strategy of the Czech Ministry of Finance (CMoF), respectively its debt management unit.

We find that the debt manager of Czech government's debt should optimally allocate about 7% of the debt into short-term CZK bills, about 16% of the debt into foreign currency bonds, 25% into CZK inflation-linked bonds, and 52% of the debt into long-term CZK bonds. The actual debt allocations implemented by the CMoF in end-2012 differ from the estimated optimal ones, particularly for the shares allocated to short-term bills and inflation-linked bonds. In particular, the CMoF allocates about 23% into short term bills compared with the suggested optimal allocation of 7% based on our estimates. The actual allocation could be viewed as more speculative and opportunistic to generate savings. However in practice, greater allocations to short-term bills could reflect other constraints such as inefficiencies in cash management or implementation of budgetary plans that the government will have to tackle first before it can move toward the optimum allocation. Moreover, because of underdeveloped inflation linked bond markets, the CMoF does not allocate any significant share of its debt into this instrument.[1] Our estimated optimal allocations for the Czech government's debt suggest that the Czech government should deepen the market for inflation linked bonds. In addition to protecting the government debt portfolio against macroeconomic shocks, efforts to develop the market

[1] In June 2012, the CMoF issued for the first time CPI inflation linked bonds for retail investors and continued to issue this type of securities since then. To date, the overall allocation of debt to this instrument remains negligible at 0.12% of the total government debt. See also: http://www.sporicidluhopisycr.cz/cs/o-dluhopisech/typy-dluhopisu/jarni-emise-12-6-2014-628.

for inflation indexed bonds could have additional positive effects on the development of the institutional investor base and enhance savings mobilization in the Czech Republic.

The remainder of the paper is organized as follows. Section 2 provides stylized facts about the development of government debt, its allocation, and servicing. Section 3 outlines theoretical underpinnings of the applied approach. Section 4 describes the employed data. Section 5 discusses the calibration of individual parameters of the model to determine optimal allocation of the Czech government debt. Section 6 discusses the empirical results. Section 7 conducts a sensitivity analysis. Section 8 concludes.

2. Stylized Facts: Management of Government Debt in the Czech Republic

After the Czech Republic's split from Slovakia in 1993, the debt of the Czech government grew substantially and increased 10.5 times by 2012. Strong growth of the Czech government debt occurred also in relation to GDP, albeit with a bit more volatility. The government debt relative to GDP increased from 15.6 to 45.7 percent, i.e. roughly tripled between 1993 and 2012 (Figure 1; panel 1,1).

Government debt managers in the Czech Republic were thus busy trying to raise the needed amount of funds while minimizing the cost and risk associated with the chosen funding strategy. Total debt servicing costs increased almost four times with the increasing level of the debt. Nevertheless, the government debt managers succeeded in steadily decreasing the debt servicing costs per Czech koruna of government debt from 9.5% to 3.4% over the 1993-2012 period. Note that this declining trend has been subject to noticeable volatility around the 1997 banking crisis and the 2008 global financial crisis (Figure 1; panel 1,2).

More explicitly, the volatility of debt servicing costs (3-year and 5-year rolling standard deviation; Figure 1; panel 2,1) decreased from 1997 to 2003 and then increased again, with the 5-year rolling measure of volatility reaching its peak in 2012. This development in the volatility of debt servicing costs raises a question whether the savings on debt servicing charges observed in panel 1,2 were indeed achieved at the same level of risk or government debt managers in the Czech Republic became much more opportunistic in their debt allocation and increased their risk taking. Although global and domestic factors may have played an important role, the allocation of government debt into more risky instruments may have been partly responsible as well.

The allocation of Czech government debt across short-term CZK debt, long-term CZK debt, and long-term foreign currency debt changed substantially over 1993-2012 (Figure 1, panel 2,2). Around 1993, the debt managers relied on the combination of short-term CZK paper and long-term foreign currency paper because of underdeveloped domestic markets for government debt. This combination exposed them to foreign currency and liquidity risks that realized mostly after the 1997 financial crisis when debt servicing costs spiked (Figure 1; panel 1,2 and panel 2,1). Aware of these risks, debt managers of Czech government debt focused on the development of domestic government bond market and allocating more debt into medium and long-term government bonds as of 2000. This reallocation was done at the expense of allocations to short-term bills and foreign currency instruments, and helped protect debt servicing costs from shocks and decrease their volatility. However, since 2006, this trend and prudent allocation has been reversed and replaced by greater and more opportunistic allocation to short-term bills followed by a slowdown and a slight reversal in the decreasing allocation to foreign currency debt. The latter might have been done for strategic reasons to preserve the presence and access to international financial markets.

[Figure 1 Here]

3. Theoretical Underpinnings

As in Giavazzi and Missale (2004), we consider the situation in which a government implements a budget consolidation plan. Further, the responsibility for financing public debt through various debt instruments is assigned to a public debt manager. His objective is to minimize the probability of unsuccessful debt consolidation owing to unexpected increase in debt service charges and debt revaluation through prudent and inexpensive debt financing.

The public debt manager faces a policy tradeoff, however. Less risky debt with low volatility of debt servicing charges is more expensive, and less expensive debt is more risky and has more volatile debt servicing charges. In our model, the debt manager can use four possible bonds to finance government debt: the short-term interest rate bond, inflation-indexed bond, foreign currency bond, and fixed interest rate bond. In view of its policy tradeoff, the debt manager selects the proportion of government debt that will be raised through short-term local-currency debt, through foreign-currency debt, through price-indexed debt, and through long-term local-currency debt.

Government debt grows with increasing servicing costs of short-term public debt in local currency, public debt in foreign currency, public debt indexed to prices, long-term public debt, and a primary fiscal deficit. Government debt also grows with its positive revaluation due to changes in exchange rates, prices, and economic performance.

The constrained optimization problem of the debt manager outlined above is formally described in Appendix 1. Solving this optimization problem under the employed assumptions gives the following results for the optimal shares of short-term debt, s^*, of foreign currency debt, q^*, and of price-indexed debt, h^*.[2]

$$\begin{aligned} s^* = & \frac{(\eta_y + B_t)}{B_t}\frac{Cov(y_{t+1}i_{t+1})}{Var(i_{t+1})} + \frac{(\eta_\pi + B_t)}{B_t}\frac{Cov(\pi_{t+1}i_{t+1})}{Var(i_{t+1})} \\ & -q^*\frac{Cov(e_{t+1}i_{t+1})}{Var(i_{t+1})} - h^*\frac{Cov(\pi_{t+1}i_{t+1})}{Var(i_{t+1})} + TP_t\frac{\sqrt{2\Pr}}{1-\sqrt{2\Pr}}\frac{E_t\left(A_{t+1} - \Delta B_{t+1}^T\right)}{B_t Var(i_{t+1})} \end{aligned} \tag{1}$$

$$\begin{aligned} q^* = & \frac{(\eta_y + B_t)}{B_t}\frac{Cov(y_{t+1}e_{t+1})}{Var(e_{t+1})} + \frac{(\eta_\pi + B_t)}{B_t}\frac{Cov(\pi_{t+1}e_{t+1})}{Var(e_{t+1})} \\ & -s^*\frac{Cov(e_{t+1}i_{t+1})}{Var(e_{t+1})} - h^*\frac{Cov(\pi_{t+1}e_{t+1})}{Var(e_{t+1})} + FP_t\frac{\sqrt{2\Pr}}{1-\sqrt{2\Pr}}\frac{E_t\left(A_{t+1} - \Delta B_{t+1}^T\right)}{B_t Var(e_{t+1})} \end{aligned} \tag{2}$$

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[2] Note that because risk and expected costs of debt service both influence the probability of debt stabilization, the objective of debt stabilization offers a solution independent of the government's risk preferences, as Giavazzi and Missale (2004) argue.

$$h^{*}=\frac{(\eta_{y}+B_{t})}{B_{t}}\frac{Cov(y_{t+1}\pi_{t+1})}{Var(\pi_{t+1})}+\frac{(\eta_{\pi}+B_{t})}{B_{t}} -q^{*}\frac{Cov(e_{t+1}\pi_{t+1})}{Var(\pi_{t+1})}-s^{*}\frac{Cov(\pi_{t+1}i_{t+1})}{Var(\pi_{t+1})}+IP_{t}\frac{\sqrt{2\Pr}}{1-\sqrt{2\Pr}}\frac{E_{t}\left(A_{t+1}-\Delta B_{t+1}^{T}\right)}{B_{t}Var(\pi_{t+1})} \quad (3)$$

Note that the optimal share of long term debt is given by $\left(1-s^{*}-q^{*}-h^{*}\right)$. In (1)-(3), η_y and η_π are elasticities of government budget to GDP with respect to output growth and inflation respectively. B_t denotes the percentage value of the government debt-to-GDP ratio. *Pr* denotes probability that the adopted stabilization plan fails, and $E_t\ (A_t - \Delta B_t^T)$ is the planned reduction in the debt-to-GDP ratio over period *T*. TP_t, FP_t and IP_t represent the term risk premium, the foreign exchange risk premium on the local relative to the foreign currency, and the inflation risk premium respectively. *Cov(.)* stands for covariance and *Var(.)* for variance of corresponding variables conditional on information available at time *t*.

More specifically, the conditional covariance of two random variables U_{t+1} and V_{t+1} can be computed as:

$$\begin{aligned}
&\text{cov}_{t}(U_{t+1},V_{t+1})=E\left\{\left[U_{t+1}-E_{t}(U_{t+1})\right]\left[V_{t+1}-E_{t}(V_{t+1})\right]\right\}\\
&U_{t+1}-E_{t}(U_{t+1})=U_{t+1}-E(U_{t+1}\,|\,\Omega_{t})=u_{t+1}\\
&V_{t+1}-E_{t}(V_{t+1})=V_{t+1}-E(V_{t+1}\,|\,\Omega_{t})=v_{t+1}\\
&\text{cov}_{t}(U_{t+1},V_{t+1})=\text{cov}(u_{t+1},v_{t+1})
\end{aligned} \quad (18)$$

where $\Omega_t=\left[\mathrm{y}_t,\ \pi_t,\ \mathrm{i}_t, \mathrm{e}_t,\ \mathrm{y}_t^*,\ \pi_t^*,\ \mathrm{i}_t^*\right]'$ and * denotes foreign economy variables. The conditional variance of two random variables U_{t+1} and V_{t+1} can then be computed analogously.

We use a vector autoregression model of order *p* (VAR(p) model) to estimate the conditional covariances and variances:

$$W_{t+1}=B\Omega_{t}+DZ_{t+1} \quad (19)$$

where $W_{t+1} = \left[\mathrm{y}_t, \pi_t, \mathrm{i}_t, \mathrm{e}_t\right]'$, B is a matrix of coefficients, and Z_t is a vector of forecast errors which are serially uncorrelated and have zero mean and unit variance. Note that $B\Omega_t = E\left[W_{t+1} \mid \Omega_t\right]$. D then contains estimates of the conditional covariances and variances of unexpected shocks:

$$D = \begin{bmatrix} \mathrm{var}_t(y_{t+1}) & \mathrm{cov}_t(\pi_{t+1}, y_{t+1}) & \mathrm{cov}_t(\varepsilon^i_{t+1}, y_{t+1}) & \mathrm{cov}_t(e_{t+1}, y_{t+1}) \\ \mathrm{cov}_t(y_{t+1}, \pi_{t+1}) & \mathrm{var}_t(\pi_{t+1}) & \mathrm{cov}_t(i_{t+1}, \pi_{t+1}) & \mathrm{cov}_t(e_{t+1}, \pi_{t+1}) \\ \mathrm{cov}_t(y_{t+1}, i_{t+1}) & \mathrm{cov}_t(\pi_{t+1}, i_{t+1}) & \mathrm{var}_t(i_{t+1}) & \mathrm{cov}_t(e_{t+1}, i_{t+1}) \\ \mathrm{cov}_t(y_{t+1}, e_{t+1}) & \mathrm{cov}_t(\pi_{t+1}, e_{t+1}) & \mathrm{cov}_t(i_{t+1}, e_{t+1}) & \mathrm{var}_t(e_{t+1}) \end{bmatrix} \tag{20}$$

The next section links the discussed model variables to observables—that is the data on the functioning of the macroeconomy of a given country, the Czech Republic in this case.

4. Data Description

Our study focuses on the Czech Republic and works with the data from the Czech economy. The foreign economy (rest-of-the world) variables are approximated by data from the Euro Area. To calibrate the model, including computation of the conditional covariances and variances, we use data on real GDP for the Czech Republic from the Czech Statistical Office, whereas nominal GDP for the Euro Area from the Eurostat, harmonized CPI, the nominal CZK/EUR exchange rate, the 3-month money market rates for the Czech Republic and the Euro Area are from the Eurostat. These data series are quarterly and span from the first quarter of 1996 to the second quarter of 2013. For the calibration of model parameters, we use the general government debt to GDP ratio in the second quarter of 2013 from the Eurostat. Further, to calibrate difference in the yields for Czech government bonds issued in domestic and foreign currency, we use the yields on 10 year government bonds in CZK and EUR in 2012 from the Czech National Bank's ARAD system and Bloomberg respectively. Government revenues and expenditures were obtained from the Czech Statistical office and span from the first quarter of 1999 to the second quarter of 2013, because earlier data on the two variables are not publicly available. All data are described in detail in Table A1 of Appendix 2.

Table A2 of Appendix 2 reports data summary statistics on all variables employed in the calibration of the model starting at the earliest available observation and ending in the second quarter of 2013.

5. Calibration of Parameters of Conditional Covariances and Variances

This section explains in detail how individual parameters entering the computation of the optimal shares of different bonds in the government debt portfolio in equations (1)-(3) are calibrated. Recall that the assumed options for the debt manager are to raise government debt using short-term bonds, foreign currency bonds, price-index bonds and long-term bonds.

5.1. Calibrating parameters

The semi-elasticities of the government budget to GDP ratio to output growth, η_y, and to inflation, η_π, were estimated as the respective correlations over 1999Q1-2013Q2. In particular, we calculated η_y as the correlation between quarterly real GDP growth and the government budget to nominal GDP ratio, and η_π as the correlation between the quarterly inflation rate and the government budget to nominal GDP ratio. Note that η_y equals 0.15 (Table 1), suggesting that the ratio of government budget to GDP improves when the economy is growing in real terms. The elasticity of the government budget to GDP ratio to CPI inflation, η_π, is estimated at 0.2. Interestingly, both calibrated parameters happen to be similar to the calibrations used by Giavazzi and Missale for Brazil. The government debt to GDP ratio, B_t, was set to 46.5 percent in line with the Czech government's indebtedness in 2013Q2.

[Table 1 Here]

The term premium, TP_t, is calculated as the last year (2012Q2-2013Q2) average of the difference between the yield of 10-year government bonds and the yield of 3-month money market rate (assumed to track the 3-month Treasury bill rate). The foreign exchange premium on the Czech koruna vis-à-vis the euro, FP_t , is computed as the last year is average of the difference between the yields on 10 year government bonds issued in CZK and EUR in domestic and euro markets respectively, less the expected percentage change in the CZK/EUR nominal exchange rate. The latter was set to zero in line with the random walk hypothesis for the exchange rates.[3] The inflation premium, IP_t, is calculated as the last year's average of the difference between actual CPI inflation at time *t* and the expected CPI inflation conditional on an information set dated *t-1*. The AR(1) process was used to generate expected inflation for simplicity. This approach was used because data on inflation expectations are not readily available and inflation linked bonds are not commonly traded.[4] We analyze the sensitivity of our results to each of these parameters later in the paper.

The probability that a given stabilization (fiscal consolidation) plan may fail is initially set at 2 percent following Giavazzi and Missale (2004, p. 9). The probability that a fiscal adjustment in the Czech Republic will fail could be slightly elevated as broadly illustrated in Appendix 3, Table B1. From 2002 to 2013, a period for which numerical targets of fiscal adjustment plans are available, most fiscal adjustment plans could be judged successful, although some of them (2006, 2007, 2009) only partly. Further research could focus on more careful assessment of the track record of the Czech government in adhering to its announced stabilization plans, most notably those involving significant fiscal consolidation. The consolidation plan, the planned reduction in the debt-to-GDP ratio, $E_t\left(A_{t+1} - \Delta B^T_{t+1}\right)$, is initially set to 1 percent. This calibration is consistent with the Czech government's plan to gradually decrease fiscal deficits and slowdown debt accumulation, and achieve

[3] Past year averages at different points in time suggested switching signs (from appreciation to depreciation) for the average trend of the exchange rate, concurring with the random walk hypothesis.

[4] Note that another simple approximation of inflation expectations could be achieved by using the Czech National Bank (CNB) inflation target at a given time, assuming perfect credibility of CNB's monetary policy and its inflation target. Alternatively, fast learning of economic agents would need to be in place to ensure that this approximation holds during a monetary policy-driven disinflationary period, as experienced by the Czech Republic.

a balanced budget in 2015. We analyze the sensitivity of our results to the two parameters later in the paper.

5.2. Calibration of conditional variances and covariances

The process of computing conditional covariances and variances consists of the following steps. First, we estimate an unrestricted VAR model with four lags (VAR(4)), as suggested by the Akaike information criterion (see Table A3 in Appendix 2). This longer lag is also theoretically required because of the year on year differences in variables that we use for the estimation and forecasts. The year on year differencing introduces up to three quarter autocorrelation by construction. The VAR contains, as endogenous variables, domestic output growth, inflation, the interest rate, and the percentage change in the CZK/EUR exchange rate. We use year on year changes in the variables to ensure that the variables are stationary. In addition, the VAR contains exogenous variables, namely the constant, time trend, as well as the foreign (Eurozone) output, inflation, and interest rate.

The variables y_t, i_t, π_t and e_t are then calculated as the forecast errors of the VAR model's static (one period ahead) forecasts of output growth, inflation, the interest rate, and the change in the exchange rate. The estimation results for the VAR(4) model are reported in Table A4 in Appendix 2. The plots of residuals from the estimated VAR are also reported in Appendix 2 in Figure A1. The residuals are well behaved apart from two large outliers. First, we can observe an outlier for the interest rate equation at the beginning of the sample that corresponds to the period before the 1997-1998 financial crisis. Second, we can observe an outlier for the real GDP corresponding to the onset of the 2008 global financial crisis. Shortening the sample or using a dummy variable to take out the outliers does not materially change the VAR estimation results.

We also inspect the actual and predicted values of the VAR variables to make sure the VAR performs well for forecasting purposes (Figure A2 in Appendix 2). The estimated VAR performs reasonably well in forecasting with the best fits produced for the interest rate and inflation variables

(Table A5 in Appendix 2). The relatively worse fit for the exchange rate could be explained by the traditionally high volatility of exchange rate series that applies also to the CZK/EUR rate.

The calibrated conditional covariances and variances based on the estimated VAR are reported in Table 2:

[Table 2 Here]

The conditional variances correspond to the variances of forecast errors for individual variables from the estimated VAR(4). The conditional variance for the exchange rate (the e,e cell) is much larger compared with other variables whereas the interest rate variance (the i,i cell) is the smallest. Also the estimated conditional covariances reveal interesting observations for government debt managers in the Czech Republic that seek to exploit natural hedges for efficient debt portfolio allocation.

Consider the covariances of GDP growth with other variables first. The covariance of GDP growth and inflation is negative and significant suggesting that business cycles could have been driven more by supply shocks than demand shocks. This conjecture is consistent with the presence of two crisis periods that involved deep recessions, in which production capacity diminished, and strong recoveries followed. This negative covariance could imply that nominal revenues for the Czech government could be more stable than in other countries in which the business cycle is primarily driven by demand shocks. The covariance of GDP growth with the interest rate is positive but insignificant, and its small magnitude suggests a weak transmission channel of monetary policy from interest rates to GDP growth. The negative sign on the covariance between GDP growth and changes in the exchange rate is consistent with the covariance between GDP growth and inflation. If GDP growth is primarily driven by supply shocks, positive supply shocks such as productivity increases should result in appreciation of CZK vis-à-vis EUR as suggested by the estimated covariance.

Consider the additional covariances of inflation with the remaining variables. The covariance of inflation with the interest rate is positive and significant in line with the expectation that monetary policy rates increase when inflation increases. The covariance of inflation with changes in the exchange rate is estimated negative but insignificant. Although the purchasing power parity hypothesis suggests that (other things equal) increasing inflation should result in depreciation of local currency and an increase in the exchange rate, the estimated negative covariance implies different transmission mechanism. We conjecture that as inflation increases and interest rates rise, capital inflows due to the increased interest rate differential could cause the exchange rate to appreciate, at least in the short term.

Consider the remaining covariance of the interest rate and changes in the exchange rate. The estimated negative covariance is only marginally significant. The estimate contradicts the hypothesis of uncovered interest parity. The estimate implies that an increasing interest rate differential on CZK vis-à-vis EUR shall result in future appreciation of the koruna within the one year horizon presumably because of higher capital inflows. This is however in line with empirical research suggesting that uncovered interest parity has a mixed performance and tends to only hold in the medium term (the 2-5 years horizon) (Chinn and Quayyum, 2012).

We further compare our calibration of the ratio of the covariances and variances entering equations (1)-(3) with those used by Giavazzi and Missale (Table A6 in Appendix 2). Overall, our calibrations differ from those of Giavazzi and Missale. Although the relative magnitudes of our calibration are in some cases similar ($Cov(e\pi)/Var(e)$, $Cov(ie)/Var(i)$, $Cov(ie)/Var(e)$) to those of Giavazzi and Missale, in other cases, they are in absolute values nine times larger ($Cov(y\pi)/Var(\pi)$) or ten times smaller ($Cov(e\pi)/Var(\pi)$) or bear a different sign altogether ($Cov(yi)/Var(i)$; $Cov(ye)/Var(e)$).

6. Discussion of Results

Using the baseline calibration of the parameters presented in Tables 1 and 2, and equations (1)-(3), Matlab's *fsolve* function's solution produces optimal shares for government debt allocation that are presented in Table 3.

[Table 3 Here]

The estimated results suggest that the manager of Czech government's debt should allocate 7.28% of the debt into short-term CZK bills (T-bills), 15.98% of the debt into foreign currency bonds, 25.16% into CZK inflation-linked bonds, and 51.58% of the debt into long-term fix-rate CZK bonds. Managing liquidity risks, repayments of longer term bonds, and cash requirements for treasury operations forces the debt manager to allocate at least a small share of government debt into short-term bills. We estimate this allocation to be about 7%. We will discuss this number in more detail shortly when comparing our optimal estimates with the actual allocations implemented by Czech debt managers.

The allocation of about 16% to foreign currency bonds could be possibly higher given the negative foreign currency premium and the implied potential savings. The potential cost savings from a greater allocation of debt into foreign currency are, however, mitigated by the relatively high conditional variance of the CZK/EUR exchange rate (the size of unexpected change in the exchange rate), and the significantly negative conditional covariance of the exchange rate with GDP growth. The former increases overall risk of allocating debt into foreign currency while having revenues in local currency. The latter suggests that when government revenues decline the CZK tends to depreciate, thus increasing debt service charges and increasing the CZK equivalent of the EUR denominated debt.

Despite the negative inflation premium (Table 1, IP), the allocation to inflation-linked bonds is substantial of about 25% of total debt. This result arises mostly because the conditional variance of unexpected changes in inflation is high and dominates the influence of the negative inflation premium. Note that the negative inflation premium alone would suggest allocation of Czech government's savings (reserves) in CZK inflation-linked paper. In practice, such allocation could be implemented by the Czech government holding savings (reserves) in inflation-linked paper issued by the Czech National Bank (CNB). Apart from benefiting from the negative inflation risk premium—that is, actual inflation lower than the expected one priced in by the market—the inflation-linked paper issued by the CNB would also hold the bank accountable for systematically undershooting its inflation target and discipline it further to adhering to it.

In theory, an increasing probability that the government will fail to fully implement its debt consolidation program increases the desired allocations to long-term debt. Because an increase in the probability of future failure of the consolidation program will result in increasing financing costs for the government, locking into a lower fixed rate enables debt managers to protect the government budget from unexpected increases in future debt service charges. For the Czech government, the probability of failure to implement its consolidation program could be slightly elevated (Appendix 3). This shows up in the estimated optimal allocation of about 52% in medium to long-term CZK debt.

Table 3 also shows the latest available data from 2012 on the actual allocation of Czech government debt across the considered options. The actual allocations are in some cases noticeably different from the estimated optimal ones. As discussed, one factor that could explain the mismatch between the actual and the optimal debt allocations is the underdeveloped market for inflation-linked bonds. But other factors could also play a role. Debt managers in the Czech Republic could be rather opportunistic in debt allocation overweighting perceived savings from larger allocation into short-term debt over the refinancing risk that derives from such allocation. However, one consideration that we have ignored, and that could justify larger allocations to short-term bills, are possibly larger cash management needs of the Czech government throughout the fiscal year to smooth the differences between the collation of government revenues and execution of government expenditures. Such needs could arise, for example, because of expected seasonality in government revenues that mismatch the government expenditure plans or from an overall inefficient implementation of government budget plans.

Finally, the near zero actual allocation of government debt to CZK denominated inflation-linked instruments is due to the fact that these instruments are not commonly issued by MoF, or otherwise commonly traded in the market. However, the estimated optimal allocation for Czech government debt implies the Czech government should further develop the market for inflation index bond to better protect its debt portfolio and the government budget from unexpected changes in debt servicing costs; notwithstanding the additional positive effects this development could have on the institutional investor base and savings mobilization.

7. Sensitivity Analysis

As in any calibration or estimation approach, there is some uncertainty around the calibrated parameters. This uncertainty could be even more important for results obtained from a non-linear model like ours. For that reason, we conduct a sensitivity analysis regarding the calibrated parameters. Such analysis shall also test the robustness of our results and gain further insights into the applicability of the results in various circumstances that the debt manager can be faced with in the future. More specifically, we vary the model parameters within a plausible range around their calibrated values, and examine how the estimated optimal shares of foreign currency, short-term local currency, inflation-indexed, and long-term local currency debt change in response. The results of such sensitivity analysis are plotted in Figure A3 in Appendix 2.

Overall, our results are rather insensitive to changes in single parameters, except for the foreign currency and inflation risk premiums (FP, IP), and the extent of the consolidation plan (the size of budget adjustment). An increasing foreign exchange premium implies progressively greater optimal allocations to foreign currency bonds and inflation-indexed bonds and smaller allocations into long-term bonds. The sensitivity results suggest that if uncertain about the FP value, debt managers should gravitate to more conservative allocations into local currency. The baseline results are also sensitive to changes in the IP. Negative IP suggests that future actual inflation will be on average greater than expected, and encourages allocation of government savings (reserves) in inflation-linked papers. In contrast, positive IP encourages some borrowing in CZK denominated, inflation-linked bonds.

The optimal debt allocation is similarly sensitive to how ambitious the fiscal consolidation plan is. A more ambitious consolidation plan implies greater allocations towards long-term fixed rate debt. This result could seem counter-intuitive if debt management is part of the fiscal savings efforts and is forced to cut cost at the expense of greater risk taking, because the probability of failure of such plan will likewise increase. However, if debt management is independent and not part of the fiscal consolidation plan, as argued by Wheeler (2004), the implications are different. The results suggest that in a risk neutral environment government consolidation may require stable debt service charges that do not introduce an unexpected cost to the budget.[5] A greater allocation to fixed rate bonds is then justified.

8. Conclusion

Sound debt management practices can help avoid unexpected increases in debt services charges, reduce debt vulnerability to macroeconomic and financial shocks, and thus prevent the occurrence of debt crises. This paper carried out an empirical analysis of the optimal debt allocation for the Czech Republic using the approach of Giavazzi and Missale (2004) and an estimated VAR model for the Czech macroeconomy.

The estimation results suggest that the Czech government should allocate most of its debt (about 52%) to long-term fixed-rate bonds. This is a smaller share than the Czech Ministry of Finance (CMoF) allocated to this instrument by end-2012 (65.9%). Further, the CMoF should allocate about 25% of its debt to inflation-linked bonds. Currently, such instrument is not widely used by debt managers in the Czech Republic and the corresponding market is underdeveloped. The results substantiate considerable efforts that the debt managers in the Czech Republic should devote to developing the market for inflation-linked bonds. The CMoF can draw on examples of other countries that have developed markets for inflation-linked bonds such as France, Germany, Italy and Sweden.

The CMoF's allocation into foreign currency bonds of 11% is broadly aligned with the suggested optimal allocation of 16%, given the uncertainty about the foreign currency premium. In contrast, the CMoF's allocation to short-term bills of 23% is significantly above the suggested optimal

[5] Strategic interactions between the government and the central bank (the monetary-fiscal mix) as well as long-term demographic factors may also play a role in determining the feasibility of a planned fiscal consolidation (Libich and Stehlik, 2012).

allocation of about 7% and could be introducing excessive risks to the debt portfolio under the assumed risk neutral preferences. In practice, the CMoF allocation to short-term bills could be driven by inefficiencies that are out of the debt manager's control, and could stem from inefficient cash management or implementation of budget plans, including tax collection and government expenditures.

More research is needed to aid formulation of robust government debt management strategies in the Czech Republic, and this paper is one of the first attempts in this direction. More broadly, further research is warranted on the optimal allocation of debt in emerging market economies that typically face a broader set of challenges than advanced economies, including those due to political economy factors.

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Tables in the Main Text

Table 1: Calibration of input parameters

Parameter	Description	Baseline Calibration	Giavazzi & Missale (2004) Calibration
η_y	Elasticity of government budget to GDP with respect to output	0.15	0.2
η_π	Elasticity of government budget to GDP with respect to inflation	0.20	0.2
B_t	Government debt to GDP (2nd quarter 2013), (in %)	46.5	57.2
TP_t	Term premium (last year average), (in %)	1.47	2.5
FP_t	Foreign Exchange Premium on CZK (last year average), (in %)	-1.19	4.3
IP_t	Inflation premium (last year average), (in %)	-0.39	1.9
Pr	Probability that stabilization plan fails, (in %)	2	2
$E_t(A_t\text{-}delthaB_t^T)$	Planned reduction in debt-to-GDP ratio over T, (in %)	1	1

Source: Authors' calculations

Table 2: Calibration of conditional covariances and variances

Variance - Covariance matrix				
	y	**Π**	**i**	**e**
y	0.367	-0.089 (0.040)	0.005 (0.018)	-0.607 (0.161)
π		0.286	0.053 (0.015)	-0.033 (0.158)
i			0.056	-0.084 (0.069)
e				5.325

Source: Authors' calculations
Note: Standard errors in the parentheses

Table 3: Estimated optimal debt allocation and actual allocation of Czech Government Debt

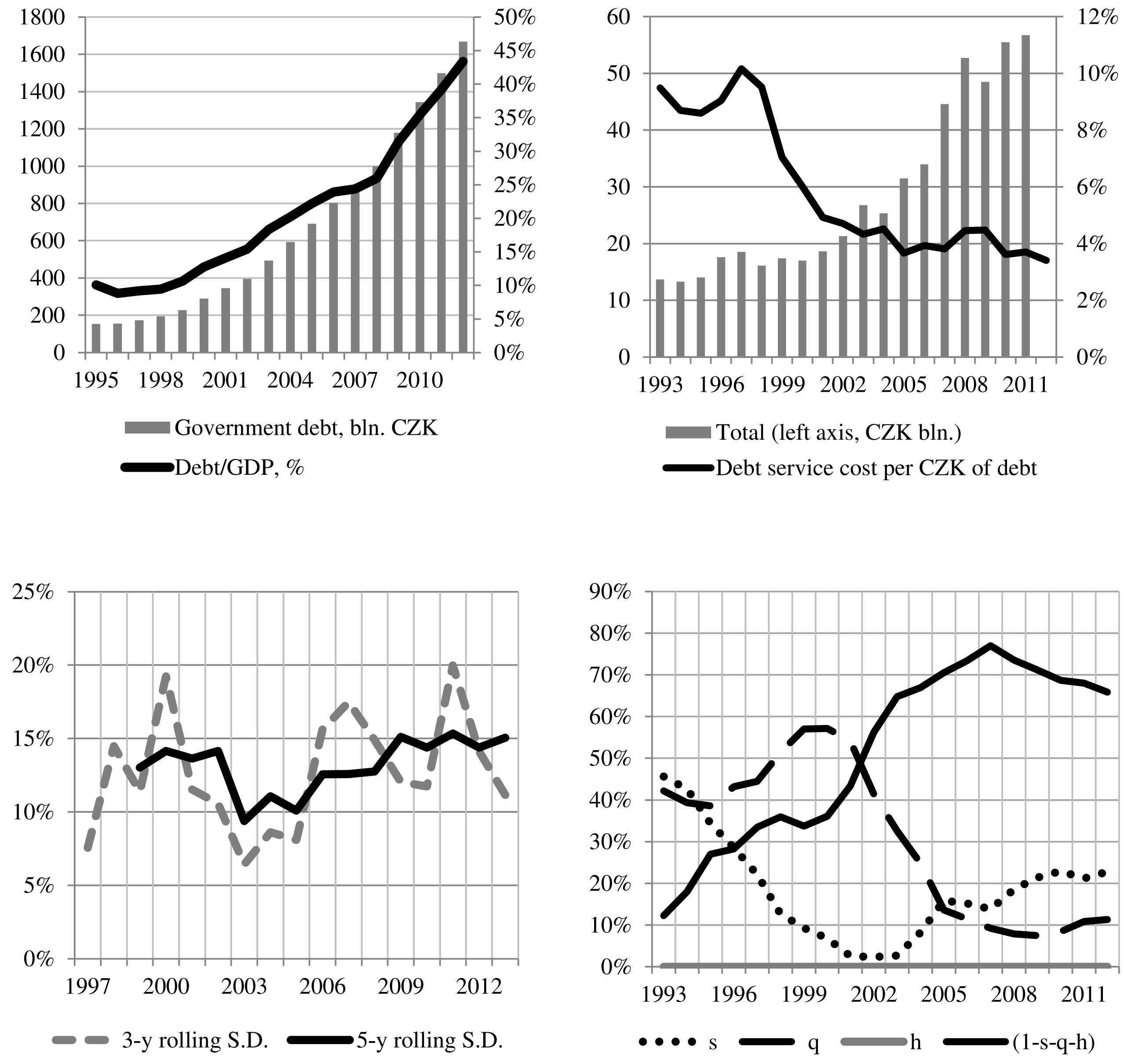
Debt Allocations	s*	q*	h*	Fix
Estimated Optimal	7.28	15.98	25.16	51.58
Actual (December 2012)	22.8%	11.3%	0.0%	65.9%

Source: Authors' calculations; CMoF Development of the Government debt.[6]
Note: s - short-term floating-rate debt, q* - foreign-currency denominated debt, h* - inflation-indexed debt, and fix - long-term fixed-rate debt, which is computed as 1-s*-q*-h**

[6] Available at: http://www.mfcr.cz/cs/verejny-sektor/hospodareni/rizeni-statniho-dluhu/dluhova-statistika/struktura-a-vyvoj-statniho-dluhu

Figures in the Main Text

Figure 1: Czech government debt (top panels) and Debt servicing costs (bottom panels)



Source: CMoF and authors' calculations

APPENDIX 1

The Optimization Problem of the Government Debt Manager

As in Giavazzi and Missale (2004), the debt manager tries to solve the following optimization problem:

A. Objective Function

$$\underset{s,q,h}{Min}\, E_t \text{Prob}\left[\text{X>A}_{\text{t+1}} - \Delta B_{t+1}^T \right] = \underset{s,q,h}{Min}\, E_t \int_{A_{t+1}-\Delta B_{t+1}^T}^{\infty} \phi(X)\, dx \ . \tag{1}$$

By choosing the proportion of public debt to be raised through short-term debt, *s*, foreign currency debt, *q*, price-indexed debt, *h*, and long-term debt (*1-s-q-h*), it minimizes the probability that the intended fiscal adjustment will fail due to unexpectedly high debt service charges or debt revaluation. E_t is expectation conditional on information available at time *t*. $\text{A}_{\text{t+1}}$ is the expected adjustment, *X* denotes the uncertain component of the fiscal adjustment, B_{t+1} is the debt-to-GDP ratio, and B_{t+1}^T is the trend debt ratio—that is, the debt ratio that would exist in period *t + 1* in the absence of the fiscal correction.

B. Constraints

The debt ratio rises if interest payments increase, primary budget surplus decreases, nominal GDP grows, or domestic currency depreciates, which affect the value of foreign currency debt. The nominal rate of return on fixed rate bonds is known at the time of issuance and equals to the long-term interest rate (*Rt*):

$$\Delta B_{t+1}^T \equiv B_{t+1}^T - B_t = I_{t+1} B_t + \Delta e_{t+1} q B_t - S_{t+1}^T - (\Delta y_{t+1} + \pi_{t+1}) B_t \ . \tag{2}$$

where $\Delta B_{t+1}^T = B_{t+1}^T - B_t$ is the debt accumulation, $I_{t+1}B_t$ are the nominal interest payments, e_t is the log of nominal exchange rate, q is the share of euro denominated bonds, S_{t+1}^T is the trend primary surplus, y_{t+1} is the log of output, and π_{t+1} is the rate of inflation.

The interest payments are as follows:

$$I_{t+1}B_t = i_{t+1}sB_t + \left(R_t^* + RP_t\right)qB_t + \left(R_t^I + \pi_{t+1}\right)hB_t + R_t\left(1 - s - q - h\right)B_t \,. \tag{3}$$

where R_t^* is the foreign interest rate, R_t^I is the real interest rate known at the time of issuance and π_{t+1} is the rate of inflation in the following period. i_{t+1} is the average interest rate between period t and $t+1$ known at time t. The return on euro denominated bonds $\left(R_t^* + RP_t\right)\left(1 + \Delta e_{t+1}\right)$ is approximated by the sum of the foreign interest rate and the risk premium (R_t+RP_t).

The ratio of the trend primary surplus to GDP is uncertain, since it depends on cyclical developments of GDP and inflation:

$$S_{t+1}^T = E_t S_{t+1}^T + \eta_y\left(y_{t+1} - E_t y_{t+1}\right) + \eta_\pi\left(\pi_{t+1} - E_t \pi_{t+1}\right). \tag{4}$$

where S_{t+1}^T is the ratio of trend primary surplus to GDP, η_y is the semi-elasticity of government budget (relative to GDP) with respect to output, η_π is the semi elasticity of budget with respect to the price level and E_t are the expectations conditional on the information at time t.

C. First Order Conditions

The government selects shares of debt instruments with respect to the first order conditions (5)-(7). The debt structure is optimal only if increased probability of failure is equalizes across debt instruments.

$$E_t\phi\left(A_{t+1} - \Delta B_{t+1}^T\right)\left[i_{t+1} - R_t\right] = 0 \tag{5}$$

$$E_t\phi\left(A_{t+1} - \Delta B_{t+1}^T\right)\left[R_t^* + RP_t + e_{t+1} - e_t - R_t\right] = 0 \tag{6}$$

$$E_t \phi\left(A_{t+1} - \Delta B_{t+1}^T\right)\left[R_t^I + \pi_{t+1} - R_t\right] = 0 \quad (7)$$

where $A_{t+1} - \Delta B_{t+1}^T$ is the planned reduction in the debt to GDP ratio and $\phi\left(A_{t+1} - \Delta B_{t+1}^T\right)$ is a function of *s*, *q* and *h*.

D. Assumed Behavioral Relationships

Based on the Giavazzi and Missale's framework, the following behavioral relationships are assumed. The difference between interest costs of short rate bonds and fixed rate bonds is given by the deviation of the average short rate from its expected value and the term premium (TP_t) on fixed rate bonds:

$$i_{t+1} - R_t = i_{t+1} - E_t i_{t+1} - TP_t \,. \quad (8)$$

The term premium is calculated from the true term premium (TP_t^I) and informational spread:

$$TP_t = TP_t^I + \left(E_t^I i_{t+1} - E_t i_{t+1}\right), \quad (9)$$

where E_t^I are investor's expectations.

The difference between the return on the euro denominated bonds (expressed in Czech koruna) and the return on fixed rate bonds is influenced by the deviation of average exchange rate from the expected exchange rate and the exchange rate risk premium:

$$R_t^* + RP_t + e_{t+1} - e_t - R_t = e_{t+1} - E_t e_{t+1} - FP_t \;. \quad (10)$$

The foreign premium is calculated from the true term premium (FP_t^I) and informational spread:

$$FP_t = FP_t^I + E_t^I e_{t+1} - E_t e_{t+1}, \quad (11)$$

where E_t^I are investor's expectations.

The difference between interest costs of price-indexed bonds and fixed rate bonds is given by the deviation of the average inflation rate from the expected inflation rate and the inflation risk premium (IP_t):

$$R_t^I + \pi_{t+1} - R_t = \pi_{t+1} - E_t\pi_{t+1} - IP_t \ . \tag{12}$$

The inflation premium is calculated from the true premium (IP_t^I) and informational spread:

$$IP_t = IP_t^I + E_t^I\pi_{t+1} - E_t\pi_{t+1} . \tag{13}$$

where E_t^I are investor's expectations.

E. Triangular Approximation of Distribution

To estimate the probability distribution function $\phi(X)$, Giavazi and Missale take a linear approximation of $\phi(X)$ across bad realizations of the fiscal adjustment X>0. This approximation yields the triangular probability density function described in (14). Greater bad realizations are thus less likely to occur than smaller ones

$$\phi(X) = \frac{\bar{X} - X}{\bar{X}^2} . \tag{14}$$

F. The Solution

Using (14), substituting (8)-(13) into (5)-(7), and rearranging gives the following solutions for the optimal shares of short-term debt, s^*, foreign currency debt, q^*, inflation-linked bonds, h^*, and fixed rate debt (1-s^*-q^*-h^*):

$$\begin{aligned} s^* = {} & \frac{(\eta_y + B_t)}{B_t}\frac{Cov(y_{t+1}i_{t+1})}{Var(i_{t+1})} + \frac{(\eta_\pi + B_t)}{B_t}\frac{Cov(\pi_{t+1}i_{t+1})}{Var(i_{t+1})} \\ & -q^*\frac{Cov(e_{t+1}i_{t+1})}{Var(i_{t+1})} - h^*\frac{Cov(\pi_{t+1}i_{t+1})}{Var(i_{t+1})} + TP_t\frac{\sqrt{2\Pr}}{1-\sqrt{2\Pr}}\frac{E_t(A_{t+1} - \Delta B_{t+1}^T)}{B_t Var(i_{t+1})} \end{aligned}, \tag{15}$$

$$
\begin{aligned}
q^* = {} & \frac{(\eta_{\mathrm{y}} + \mathrm{B_t})}{B_t} \frac{Cov(y_{t+1} e_{t+1})}{Var(e_{t+1})} + \frac{\left(\eta_{\pi} + B_t\right)}{B_t} \frac{Cov\left(\pi_{t+1} e_{t+1}\right)}{Var\left(e_{t+1}\right)} \\
& - s^* \frac{Cov\left(e_{t+1} i_{t+1}\right)}{Var(e_{t+1})} - h^* \frac{Cov(\pi_{t+1} e_{t+1})}{Var(e_{t+1})} + FP_t \frac{\sqrt{2\,\mathrm{Pr}}}{1 - \sqrt{2\,\mathrm{Pr}}} \frac{E_t\left(A_{t+1} - \Delta B_{t+1}^T\right)}{B_t Var(e_{t+1})}
\end{aligned}, \tag{16}
$$

$$
\begin{aligned}
h^* = {} & \frac{(\eta_{\mathrm{y}} + \mathrm{B_t})}{B_t} \frac{Cov(y_{t+1} \pi_{t+1})}{Var(\pi_{t+1})} + \frac{\left(\eta_{\pi} + B_t\right)}{B_t} \\
& - q^* \frac{Cov\left(e_{t+1} \pi_{t+1}\right)}{Var(\pi_{t+1})} - s^* \frac{Cov(\pi_{t+1} i_{t+1})}{Var(\pi_{t+1})} + IP_t \frac{\sqrt{2\,\mathrm{Pr}}}{1 - \sqrt{2\,\mathrm{Pr}}} \frac{E_t\left(A_{t+1} - \Delta B_{t+1}^T\right)}{B_t Var(\pi_{t+1})}
\end{aligned}. \tag{17}
$$

APPENDIX 2

Tables

Table A1: Description of data and data sources

Variable	Characteristic	Source
Nominal GDP – EA	GDP in current prices, seasonally adjusted and adjusted data by working days, millions of euro (from 1.1.1999)/millions of ECU (up to 31.12.1998), for CR and EA	EUROSTAT
Real GDP - CR	GDP in constant prices (2005=100), billions of CZK	CNB's ARAD
HCPI	Harmonized consumer price index, 1996=100, seasonally adjusted, index, all-items HICP, for CR and EA Calculated as 3-month average from monthly data	EUROSTAT
Exchange rate	Nominal bilateral exchange rate CZK/EUR (ECU), quarterly average	EUROSTAT
3M Money Market interest rate	3-month Money market interest rate, for CR and EA Series are based on national methodologies. EONIA and Euribor (see: http://www.euribor.org) follow a European methodology. Both use the same panel of banks.	EUROSTAT
10Y bond yield	10-year maturity treasury bond yield (Maastricht criterion)	CNB's ARAD
Government revenues	Total general government revenues	CSO
Government expenditures	Total general government expenditures	CSO
Debt to GDP ratio	General government gross debt as % of GDP	EUROSTAT

Note: CR = Czech Republic, EA = Euro Area (EA11-2000, EA12-2006, EA13-2007, EA15-2008, EA16-2010, EA17). CNB = the Czech National Bank, CSO = the Czech Statistical Office. Government revenues and expenditures were obtained from: http://apl.czso.cz/pll/rocenka/rocenkavyber.gov_p?mylang=CZ.

Table A2: Data summary statistics

Data availability	1996Q1-2013Q2							1999Q1-2013Q2		2000Q3-2013	2000Q1-2013Q2
Variable	**3M interest rate CR**	**3M interest rate EA**	**nominal exchange rate CZK/EUR**	**HCPI CR**	**HCPI EA**	**real GDP CR**	**nominal GDP EA**	**government expenditures CR**	**government revenues CR**	**10Y bond yield CR**	**debt to GDP ratio CR**
Mean	4.88	2.92	30.44	137.73	117.08	755.39	1944056	345621	315333	4.34	30.64
Median	2.73	3.10	30.32	136.67	116.25	740.05	1956774	360548	330622	4.15	28.55
Maximum	19.69	5.63	37.75	169.20	138.87	914.80	2395462	511701	413931	7.38	47.90
Minimum	0.46	0.20	24.09	97.37	99.33	600.20	1395031	191637	184385	1.92	16.00
Std. Dev.	4.65	1.50	4.37	18.89	12.00	120.87	333325	72842	66581	1.20	7.89
Skewness	1.52	-0.21	0.09	-0.22	0.17	0.01	-0.21	-0.27	-0.36	0.41	0.43
Kurtosis	4.28	1.86	1.61	2.28	1.75	1.31	1.62	2.45	1.92	3.25	2.79
Jarque-Bera	31.88	4.26	5.71	2.09	4.91	8.35	6.07	1.42	4.09	1.66	1.78
Probability	0.00	0.12	0.06	0.35	0.09	0.02	0.05	0.49	0.13	0.44	0.41
Sum	341.27	204.29	2130.93	9641.20	8195.63	52877.20	1.36E+08	20046041	18289327	230.28	1654.60
Sum Sq. Dev.	1489.66	155.64	1315.20	24608.98	9942.30	1008138.00	7.67E+12	3.02E+11	2.53E+11	75.16	3298.33
Observations	70	70	70	70	70	70	70	58	58	53	54

Source: Authors' calculations

Table A3: VAR lag length selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-495.3471	NA	195.1944	16.62410	17.31027	16.89351
1	-297.8647	337.6312	0.563596	10.76983	12.00494*	11.25476
2	-270.0976	43.88997	0.392189	10.39024	12.17429	11.09071
3	-246.3852	34.42116*	0.315860*	10.14146	12.47444	11.05745*
4	-229.5004	22.33147	0.323941	10.11292*	12.99484	11.24443

Source: Author's calculations

*Note: * indicates lag order selected by the criterion; LR: sequential modified LR test statistic (each test at 5% level); FPE: Final prediction error; AIC: Akaike information criterion; SC: Schwarz information criterion; HQ: Hannan-Quinn information criterion*

Table A4: Estimation Results for VAR(4)

	RGDP	INFL	IR	ER
RGDP(-1)	0.944154	0.097568	0.064715	-0.757007
	(0.17702)	(0.15617)	(0.06925)	(0.67435)
RGDP(-2)	-0.191271	-0.134499	0.005494	1.834801
	(0.24330)	(0.21465)	(0.09518)	(0.92684)
RGDP(-3)	-0.143462	-0.061505	-0.245588	-0.637650
	(0.23513)	(0.20744)	(0.09198)	(0.89572)
RGDP(-4)	0.305405	0.122711	0.174240	-0.185175
	(0.15102)	(0.13324)	(0.05908)	(0.57532)
INFL(-1)	-0.161868	0.656698	0.149358	-0.390164
	(0.18120)	(0.15986)	(0.07089)	(0.69027)
INFL(-2)	0.133689	-0.106678	0.105574	0.250111
	(0.20637)	(0.18207)	(0.08073)	(0.78617)
INFL(-3)	-0.487412	-0.053229	-0.116308	-0.340472
	(0.18457)	(0.16284)	(0.07220)	(0.70311)
INFL(-4)	-0.018741	-0.129823	-0.112779	0.261474
	(0.16272)	(0.14356)	(0.06366)	(0.61988)
IR(-1)	0.125314	0.240645	0.843043	0.826618
	(0.35273)	(0.31119)	(0.13799)	(1.34372)
IR(-2)	-0.004186	-0.106893	-0.270611	-2.136574
	(0.38644)	(0.34093)	(0.15117)	(1.47211)
IR(-3)	-0.021189	0.357610	0.161256	1.668067
	(0.19071)	(0.16826)	(0.07461)	(0.72652)
IR(-4)	0.183973	-0.145287	0.086230	-0.068094
	(0.14095)	(0.12435)	(0.05514)	(0.53693)
ER(-1)	-0.092875	0.134966	0.043185	0.807108
	(0.04520)	(0.03988)	(0.01768)	(0.17218)
ER(-2)	0.057226	-0.047340	-0.005866	-0.267476
	(0.05137)	(0.04532)	(0.02010)	(0.19570)
ER(-3)	-0.042824	0.019727	-0.041272	0.066444
	(0.05259)	(0.04640)	(0.02057)	(0.20035)
ER(-4)	0.086470	0.012986	0.000298	-0.102993
	(0.04425)	(0.03904)	(0.01731)	(0.16856)
C	1.370959	-3.555259	-0.116531	-0.000308
	(0.98572)	(0.86964)	(0.38562)	(3.75506)
@TREND	-0.001914	0.042810	0.003879	0.022981
	(0.01471)	(0.01297)	(0.00575)	(0.05602)
RGDP_ EA	0.159003	0.033647	0.066339	-0.508969
	(0.09947)	(0.08775)	(0.03891)	(0.37892)
INFL_EA	-0.071873	0.824043	-0.109733	-0.912991
	(0.26528)	(0.23405)	(0.10378)	(1.01059)
IR_EA	-0.256919	0.365698	0.162652	-0.333722
	(0.17430)	(0.15378)	(0.06819)	(0.66399)
R-squared	0.961285	0.954902	0.994757	0.806274
Adj. R-squared	0.942400	0.932903	0.992199	0.711773
Sum sq. resids	23.11538	17.99185	3.537563	335.4493
S.E. equation	0.750859	0.662439	0.293738	2.860365
F-statistic	50.90160	43.40680	388.9489	8.531932
Log likelihood	-57.38847	-49.62050	0.800396	-140.3126
Akaike AIC	2.528660	2.278081	0.651600	5.203633
Schwarz SC	3.249141	2.998562	1.372081	5.924114
Mean dependent	2.573764	2.917576	3.696613	-2.056605
S.D. dependent	3.128587	2.557381	3.325815	5.327876
Determinant resid covariance (dof adj.)		0.100860		
Determinant resid covariance		0.019288		
Log likelihood		-229.5004		
Akaike information criterion		10.11292		
Schwarz criterion		12.99484		

Source: Author's calculations

Note: Standard errors in ( ); Sample (adjusted): 1998Q1 2013Q2, 62 observations; RGDP is real GDP growth, INFL is inflation, IR denotes interest rate and ER is Exchange rate growth, foreign variables are denoted as follows RGDP_EA – real GDP growth, INFL_EA – inflation, IR_EA – interest rate.

Table A5: Forecast statistics for the estimated VAR

Forecast:	ER_f	INFL_f	IR_f	RGDP_f
Forecast sample:	1998Q1 - 2013Q2	1998Q1 - 2013Q2	1998Q1 - 2013Q2	1998Q1 - 2013Q2
Root Mean Squared Error:	2.326042	0.538694	0.238867	0.610597
Mean Absolute Error:	1.926394	0.432844	0.183712	0.445483
Mean Abs. Percent Error:	138.6233	43.22962	11.16407	25.79565
Theil Inequality Coefficient:	0.214528	0.070010	0.024120	0.076164

Source: Author's calculations
Note: RGDP is real GDP growth, INFL is inflation, IR denotes interest rate and ER is Exchange rate growth, _f denotes forecasted variables.

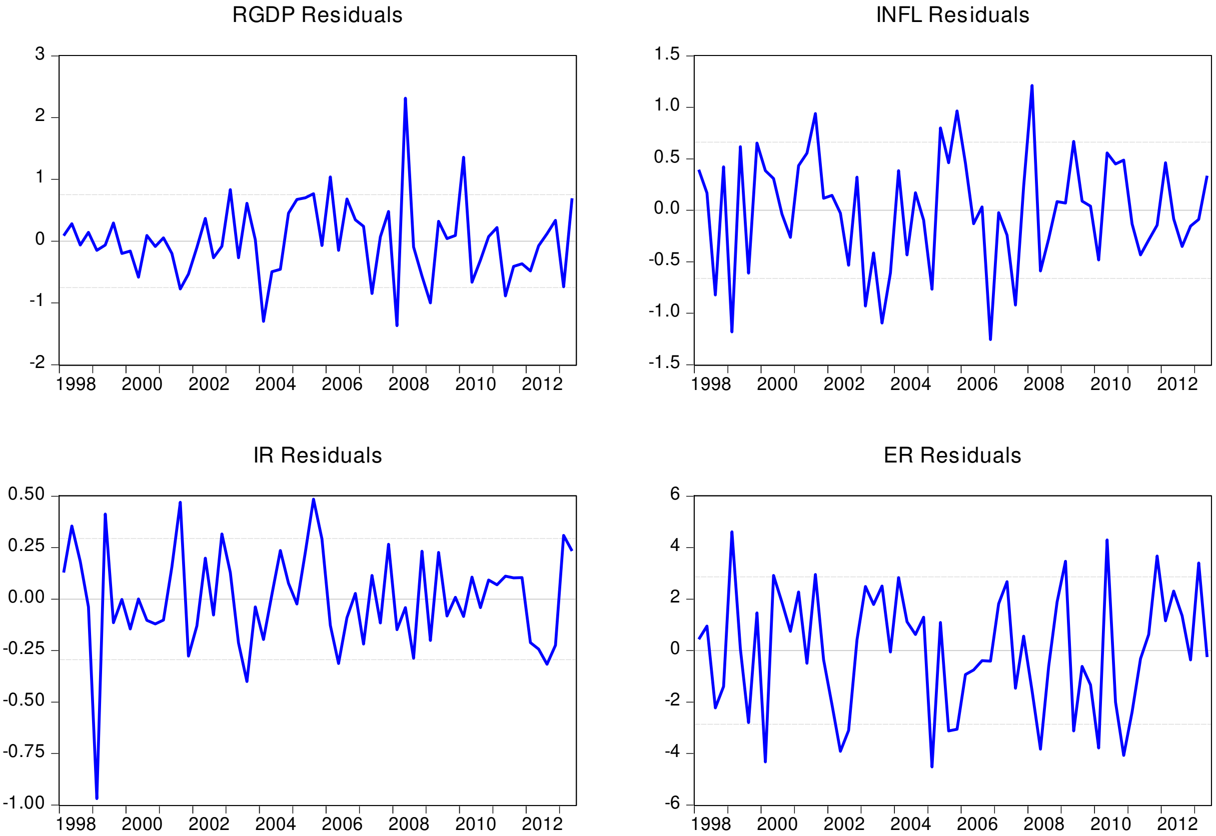
Table A6: Comparison of calibrated covariance-variance ratios to Giavazzi and Missale

Baseline Calibration				*Giavazzi a Missale (2004)*			
Covariances entering the model				**Covariances - forecasting regression - TABLE 10**			
Cov(yi)/Var(i)	0.0944	**Cov(iπ)/Var(i)**	0.9488	**Cov(yi)/Var(i)**	-0.5360	**Cov(iπ)/Var(i)**	-0.0160
Cov(ye)/Var(e)	-0.1140	**Cov(eπ)/Var(e)**	-0.0062	**Cov(ye)/Var(e)**	0.0180	**Cov(eπ)/Var(e)**	-0.0170
Cov(yπ)/Var(π)	-0.3108	**Cov(eπ)/Var(π)**	-0.1149	**Cov(yπ)/Var(π)**	-0.0420	**Cov(eπ)/Var(π)**	-1.1700
Var(i)	0.0006	**Cov(ie)/Var(i)**	-1.4908	**Var(i)**	0.0120	**Cov(ie)/Var(i)**	-2.1660
Var(e)	0.0532	**Cov(ie)/Var(e)**	-0.0157	**Var(e)**	0.8990	**Cov(ie)/Var(e)**	-0.0270
Var(π)	0.0029	**Cov(iπ)/Var(π)**	0.1866	**Var(π)**	0.0130	**Cov(iπ)/Var(π)**	-0.0140

Source: Author's calculations and Giavazzi and Missale (2004)

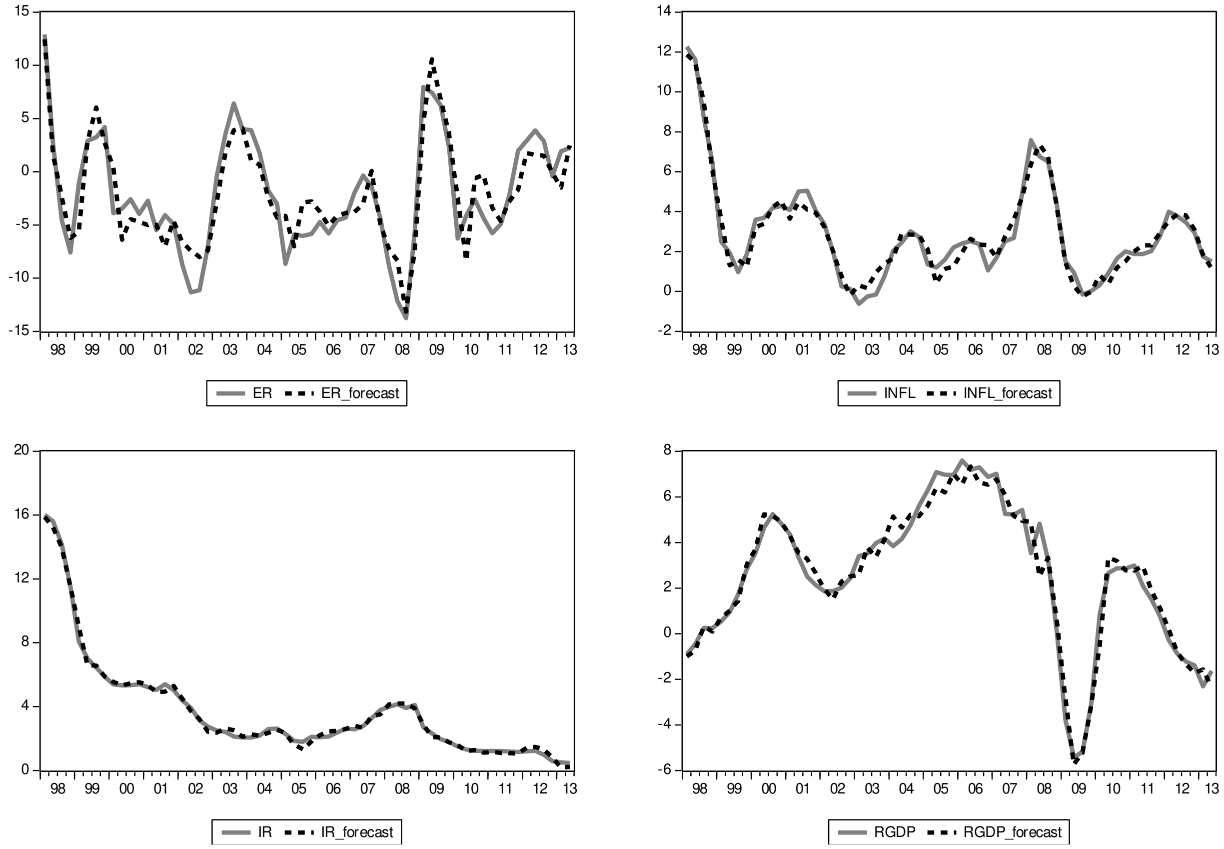
Figures

Figure A1: Plots of the estimated VAR residuals



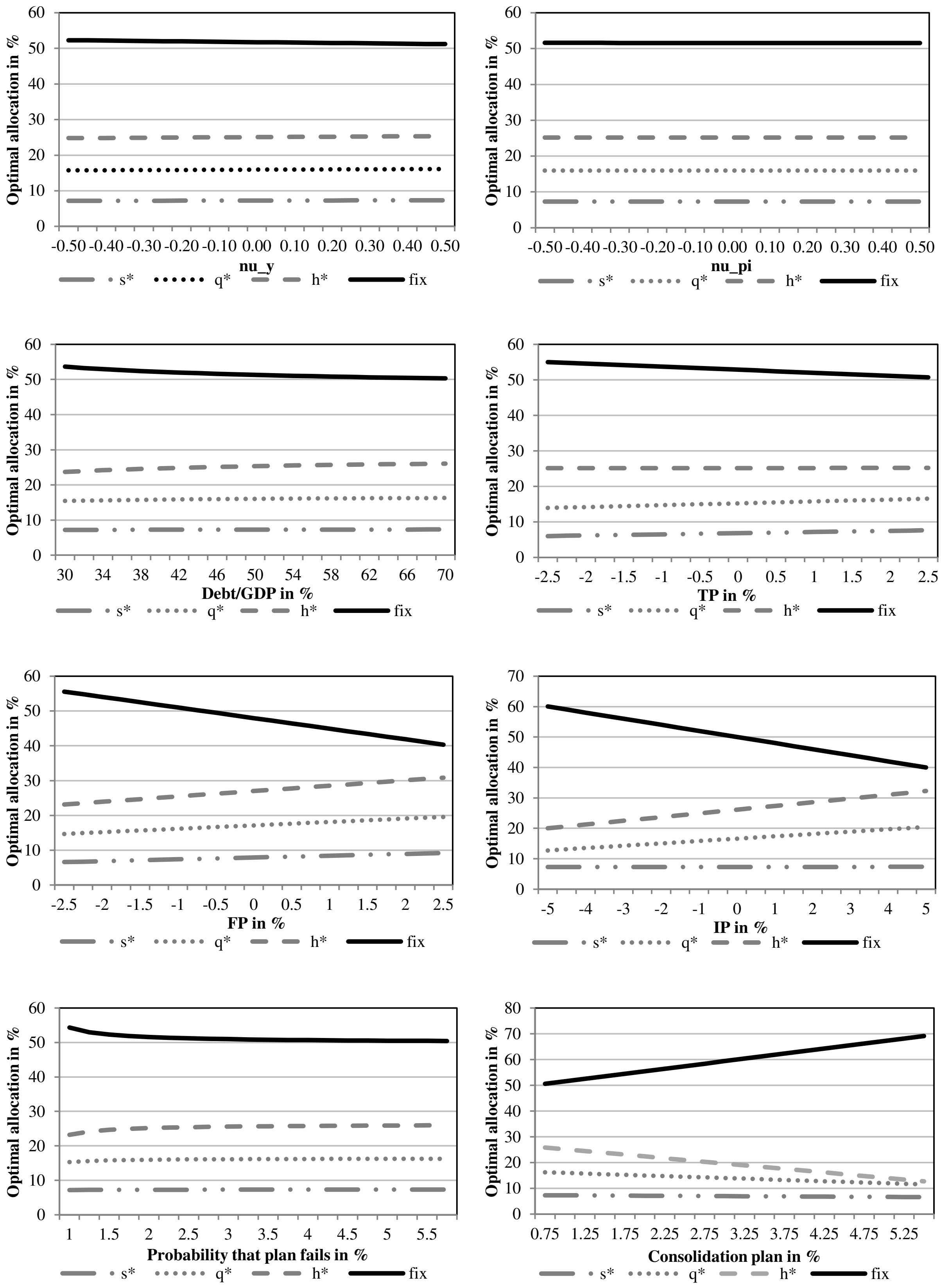
Source: Author's calculations
Note: RGDP is real GDP growth, INFL is inflation, IR denotes interest rate and ER is Exchange rate growth

Figure A2: One-step ahead forecast fits of the estimated VAR



Source: Author's calculations
Note: RGDP is real GDP growth, INFL is inflation, IR denotes interest rate and ER is Exchange rate growth

Figure A3: Results of the sensitivity analysis



Source: Author's calculations

APPENDIX 3

Table B1: Fiscal adjustment plans of the Czech government and estimates of their success

Date	Prime Minister	Adjustment Plan	Successful Yes/Partly/No
2013	Jiří Rusnok	The government shall keep the fiscal deficit below 3% of GDP to conclude the procedure of excessive deficit imposed on the Czech Republic by the European Commission.	**YES**
2010	Petr Nečas	The government is determined, under the assumption of continued economic growth, to reach balanced budget (zero fiscal deficit) in 2016. A precondition for this goal is the aim to bring the fiscal deficit at or below 3% of GDP in 2013.	**YES** 2013 goal partly 2016 goal PARTLY YES
2009	Jan Fischer	The government is to undertake steps to reduce government expenditures in 2009 to ensure that the fiscal deficit will not exceed 5% of GDP based on the ESA 95 methodology. In parallel, the government's goal is to propose government budget for 2010 with a deficit of less than CZK 170 billion, that is 5% of GDP.	**PARTLY** 2009 goal NO, 2010 goal YES
2007	Mirek Topolánek II.	The government is committed to reduce the fiscal deficit in upcoming years to the following levels: 3% of GDP in 2008, 2.6% of GDP in 2009, and 2.3% of GDP in 2010.	**PARTLY** 2008 goal YES, 2009 goal NO, 2010 goal NO
2006	Mirek Topolánek I.	*The government did not set for itself any parametric goal, it merely stated that:* the government will aim to stabilize public finances and gradually reduce fiscal deficit to ensure that a balanced budget can be developed in the long term.	**PARTLY** 2007 deficit decreased compared to 2006
2005	Jiří Paroubek	The government commits to reaching a fiscal deficit significantly below 4% of GDP in 2006, and establishing a trend that shall ensure the deficit will not exceed 3% of GDP as of 2008.	**YES**
2004	Stanislav Gross	The government shall continue reducing the fiscal deficit and bring it below 4% of GDP by 2006 and below 3% of GDP by 2008.	**YES**
2002	Vladimír Špidla	The government will commence a broad-based discussion about the reform of public finances to ensure that the fiscal deficit will stay in the range of 4.9-5.4% of GDP in 2006, and show a decreasing trend in the subsequent years.	**YES** 2006 goal YES, Declining Trend Deficit in 2007 YES

Source: Authors based on Government of the Czech Republic web pages <http://www.vlada.cz/en/> and Eurostat data

Note: Targeted and actual fiscal balances are not based on cyclically adjusted numbers, which could have been more appropriate as the current best practice suggests