KIEL

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PAPER

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No. 2123 April 2019

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Kiel Institute for the World Economy
ISSN 1862–1155

ABSTRACT

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JEL classification: E62; H61; H68.

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April 18, 2019

Abstract

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1 Introduction

Continuous public deficits and rising debt-GDP ratios in many countries around the world demonstrate the need to better understand the determinants of budgetary outcomes. Most countries have adopted some form of multi-year fiscal planning to reduce the emphasis on short-run developments and to better account for fiscal challenges in the medium run (Vlaicu et al. (2014), Auerbach (2006)). A key input for the fiscal planning process are forecasts of tax revenues in coming years. Based on the forecasted revenues, the government determines future expenditures. It is well known, however, that GDP and tax revenue forecasts are often subject to substantial revisions (Cimadomo (2016), Beetsma et al. (2009)), and typically, the revisions increase with the length of the forecast horizon. This leads to the question to what extent the government's expenditure plans get adjusted when tax revenue forecasts get revised or, in other words, to what extent revenue forecast errors translate into the final budget balance. It also raises the question at which forecast horizon the revenue forecast errors have the most significant impact on the final budget balance of a given year. The aim of this paper is to empirically analyze both of these questions.

There are several difficulties when investigating the impact of revenue forecast errors on the budget balance in order to gain insight into the process of fiscal planning. Revenue forecasts can be politically influenced if policymakers seek for a justification of higher expenditures or want to signal a more prosperous stance of the economy (Jochimsen and Lehmann (2017), Pina and Venes (2011)). Since the politically uninfluenced forecast is unknown in this case, such political considerations might lead to an errors-in-variables problem and to biased estimates. Furthermore, the link between revenue forecast errors and budgetary outcomes might be mismeasured, if fiscal policymakers actively react to the revenue forecasts by changing tax rates. For instance, lower taxes in reaction to a high revenue forecast affect the final revenues and, thus, the forecast error while possibly leaving the budget balance unchanged.[1] This would result in underestimating the true impact of the forecast errors. Similarly, extraordinary public spending in response to business cycle fluctuations could also affect final revenues and the forecast error due to possible multiplier effects.

For these reasons, we make use of a unique data set of real-time revenue forecasts for the entirety of German states ('Länder') to analyze the relevance of medium run forecast errors. This set of revenue forecasts is not produced by the government but by an indepen-

[1] Note that fiscal forecasts are usually made under a no-policy-change assumption.

dent fiscal institution, namely the Working Party on Tax Revenue Estimates ('Arbeitskreis Steuerschätzungen', AKS). Since 1955, the AKS serves as an official advisory council for the German Federal Ministry of Finance and includes, inter alia, external experts from different research institutes, the staff of the German council of economic experts and the German central bank.[2] Using these forecasts and focusing on the entirety of German states has several advantages. First, the states have very little power to politically influence the AKS forecasts. Second, the individual states in Germany have almost no tax sovereignty, which prevents any significant tax changes induced by relatively high or low revenue forecasts.[3] Third, expenditures of German states are only marginally driven by business cycle fluctuations, in contrast to the expenditures of the German federal government, and the states are also only marginally engaged in active fiscal policy in response to the cycle. Thus, business cycle fluctuations mainly affect the budgetary outcomes via variations in tax revenues. We therefore argue that the forecasts and forecast errors are largely exogenous to policy makers at the state level, which offers a relatively clean way to identify the impact of revenue forecast errors on the budgeting process. Furthermore, due to similar regulations and budgetary frameworks the results of this analysis might as well apply not only to the fiscal planning of the German federal government but also to the fiscal planning of other countries in the European Union.

Our results show that revenue forecast errors translate to a large extent into the final budget balance. In particular, we find that forecast errors at various forecast horizons matter. Not only the one-year ahead forecast errors but also the two-year and three-year ahead forecast errors significantly affect the budgetary outcome. The average revenue forecast error across all forecast horizons ultimately enters with around four-fifth in the budget balance. Our results therefore indicate that expenditure plans for future years adjust only to a minor degree to revisions in tax revenue forecasts. Consequently, the accuracy of medium run forecasts can have a sizeable impact on the sustainability of public finances. Some back-of-the-envelope calculations suggest that a significant share of total debt of German states results from revenue forecasts that were too optimistic.

So far, the empirical evidence on the consequences of revenue forecast errors has been rather limited. One exception is Chatagny and Soguel (2012) who use panel data from Swiss cantons between 1980 and 2002 to analyze the impact of tax revenue budgeting errors on fiscal deficits. They find that underestimating tax revenues significantly reduces

[2] See Büttner and Kauder (2015) for a discussion of the independence of the AKS.

[3] The only (minor) exception is the so-called real estate turnover tax, which was introduced in the year 2006.

fiscal deficits. Taking a broader perspective on the drivers of ex post budgetary outcomes, Beetsma et al. (2009) decompose the budget balance of countries of the European Union into planned and error components and explore their economic and political determinants. They inter alia report that planned positive budgetary adjustments are more than offset by negative implementation errors, thereby producing negative actual adjustments. Beetsma et al. (2013) perform a similar analysis for the Netherlands. Moreover, Cimadomo (2012) emphasizes the role of forecast errors in the cyclical component of GDP for the stance of fiscal policy, estimating fiscal reaction functions based on real-time data of OECD countries.

We contribute to this literature in several ways. First, the nature of our forecast data provides a rare opportunity to abstract from the influence of a broad set of political factors, which are often hard to measure and to control for. We are therefore able to study the impact of revenue forecasts and respective errors that can be considered as exogenously given in the budgeting process. Second, in contrast to other studies we explicitly take into account forecast errors at different horizons. This allows us to shed light on the most relevant horizons and to better understand the process of fiscal planning in general. Beyond that, the results of our paper may also add to the ongoing discussion of fiscal rules by pointing to the need of a framework that prevents biased forecasts to destabilize public debt.[4]

The structure of our paper is as follows. We first present the data set and the empirical framework (Section 2). We then discuss our main results regarding the impact of forecast errors on the budget balance, run alternative specifications to check for the robustness of our results, and have a closer look at different horizons as well as potential asymmetric effects (Section 3). Based on the previous empirical estimates we finally explore the consequences of forecast errors on the debt-GDP ratio (Section 4). Section 5 concludes.

2 Empirical framework

2.1 Data

For our analysis, we use the AKS medium run tax revenue forecasts for the entirety of German states. We obtain these data directly from the AKS. The AKS medium run forecasts comprise estimates for the current year and the following four years. While the AKS as an independent institution exists since 1955, the complete set of estimates

[4] See European Commission (2018) for a review of fiscal surveillance and fiscal rules in the European Union.

for all five horizons is only available from 1972 onwards. Our sample therefore starts in 1976. In recent years, the AKS conducts two forecasting rounds each year, one in spring and one in autumn. We take the spring forecasts from each year because during the period from 1986 to 2011 there were no medium run projections in autumn. The spring forecasts are usually published in May. In the years before 1986, however, the release of the first forecast in each year varied between February (1972, 1978) and August (1973, 1975-1977). Nevertheless, our setup offers the best possible comparability of the forecasts over time and horizons. All other (ex post) fiscal data are obtained from the German Federal Statistical Office.

We focus on the entirety of German states for the simple reason that even though the AKS also divides its forecast of total tax revenues into the tax revenues of individual states, these calculations are destined exclusively for the state governments and not made publicly available.[5] The subsequent own fiscal forecasts of the individual states are publicly available. However, since the states are not bound to the input of the AKS their forecasts are prone to political considerations (Bischoff and Gohout (2010)) and therefore not useful for our analysis. Due to the reunification the overall number of German states increased from 11 to 16 in October 1990 while the forecasts made in the late '80s for the early '90s refer to the former 11 states only. For this reason, we stick to the entirety of 11 states until the year 1994. This is possible, since the AKS separately reported forecasts for the old 11 as well as the 5 new states in the first years after the reunification. From 1995 onwards we then include all 16 states.

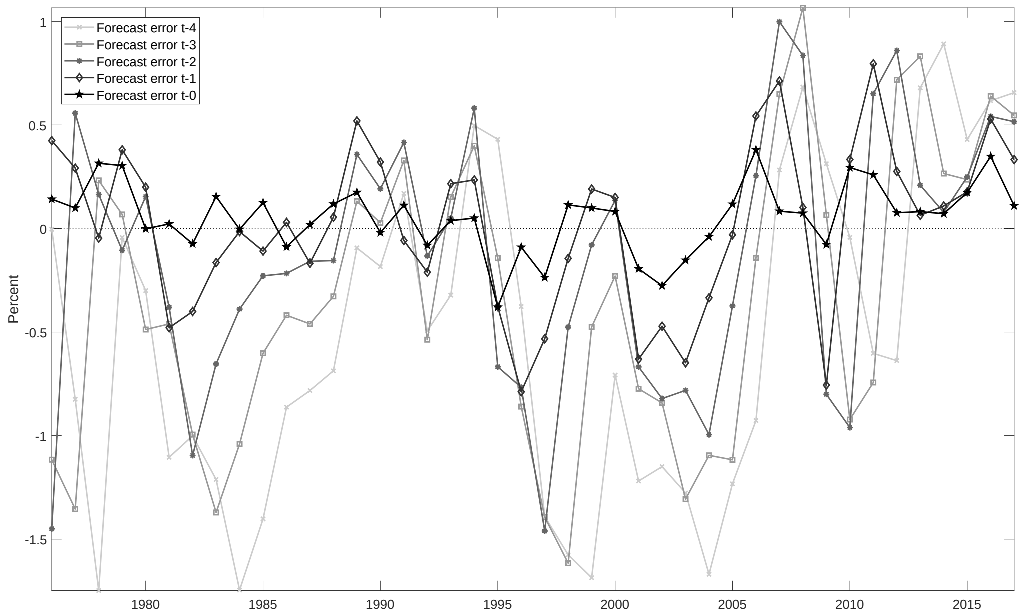
Figure 1 shows the revenue forecast errors of the AKS at different horizons, expressed in relation to nominal GDP. The forecast errors are defined as the difference between the ex-post tax revenues in a given period t and the real-time forecasts for the tax revenues in t made in period $t - i$. As expected, the forecast errors are usually smaller the shorter the forecast horizon. The mean absolute error decreases from around 0.8 for the four-year ahead forecast to nearly 0.1 for the current year forecast (Table 1). The mean error for the current year forecast and the one-year ahead forecast is positive but small, which means that at these horizons revenues are on average slightly underestimated. At longer horizons (two-, three- and four-year ahead forecast) the mean error is considerably negative, which means that on average revenues are overestimated. We will get back to the notable upward-bias of the the medium run forecasts in Section 4.[6] Chronologically,

[5]See Federal Ministry of Finance (2019) for details.

[6]Note that a bias in (medium run) forecasts is not unusual and also found in forecasts of other independent institutions like the IMF (IEO (2014)). A bias in the medium run tax revenue forecasts for the general German government is documented in Breuer (2015). Based on a sample of OECD countries Büttner

we observe periods in which tax revenues were overestimated especially around the years 1981 to 1985 and 1997 to 2005. By contrast, tax revenues in the late '80s and early '90s as well as in the more recent years from 2011 onwards were underestimated.

Figure 1: Revenue forecast errors 1976-2017



Notes: Revenue forecast errors in relation to nominal GDP at different forecast horizons.

Table 1: Revenue forecast errors - summary statistics

	Mean error	Mean absolute error	RMSE
Forecast error $t-4$	-0.52	0.78	0.93
Forecast error $t-3$	-0.34	0.65	0.77
Forecast error $t-2$	-0.14	0.51	0.63
Forecast error $t-1$	0.01	0.32	0.39
Forecast error $t-0$	0.06	0.14	0.17

Notes: Revenue forecast errors in relation to nominal GDP at different forecast horizons. Sample 1976-2017. RMSE: Root mean squared error.

2.2 The regression model

We denote the tax revenue forecast made in year $t-i$ for the year t, expressed in relation to nominal GDP Y_t, by $r_{t|t-i}$. Accordingly, $f_{t|t-i} = (r_t - r_{t|t-i})$ denotes the corresponding

and Kauder (2010), however, find that the precision of revenue forecasts increases with the independence of forecasts from possible government manipulations.

forecast error. We are interested in the effect of the forecast error $f_{t|t-i}$ at different forecast horizons $t-i$, $i=0,1,...,4$, on the final primary balance-GDP ratio p_t. Our baseline specification takes the form:

$$p_t = \alpha + \sum_{i=0}^{4} \beta_i f_{t|t-i} + \gamma \mathbf{x}_t + \delta \mathbf{d}_t + u_t. \quad (1)$$

The vector $\mathbf{x}_t$ comprises additional explanatory variables. We consider an estimate of the output gap (g_t) based on the Hodrick-Prescott filtered real GDP series and the debt-GDP ratio of the previous year (b_{t-1}).[7] The vector $\mathbf{d}_t$ comprises a set of dummy variables to control for extraordinary fiscal events and changes in the system of public finances in the years following the German reunification. In particular, we use dummy variables that have a value of 1 in the years 1992, 1993, and 1994, respectively.

When estimating (1) there might be problems of serial correlation and endogeneity. Serial correlation of the errors is a large issue, as signaled by a Durbin-Watson statistic of around 0.8. To address it, we follow Plödt and Reicher (2015) and model u_t as an autoregressive process. More specifically, u_t is assumed to follow an AR(2) process with persistence coefficients ρ_1 and ρ_2, i.e.

$$u_t = \rho_1 u_{t-1} + \rho_2 u_{t-2} + \varepsilon_t, \quad (2)$$

where ε_t is independent over time. The choice of AR(2) errors is motivated by the fact that we still find evidence for serial correlation when employing a specification with first-order AR errors only.[8] A problem of endogeneity would arise when the budget balance reacts to the output gap and the output gap is affected in turn by fiscal policy. In our context, however, this simultaneity is likely to be minor since the individual states are only marginally engaged in active fiscal policy. We therefore refrain from an instrumental variable approach. In Section 3.2 we perform several sensitivity analyses with respect to our chosen baseline specification.

[7] We take the output gap series for Germany from the European Commission's AMECO database. Our results remain almost unchanged when using an estimate of the output gap based on the European Commission's production function approach instead of the Hodrick-Prescott filter.

[8] The choice of this specification is also supported by different information criteria (see Table 2).

3 Forecast errors and fiscal planning

3.1 Baseline results

The estimation results for our baseline specification are presented in Table 2 (specification A1). Our main finding is that not only the one-year ahead forecast errors but also the two-year and three-year ahead forecast errors have an economically and statistically significant effect on the primary balance-GDP ratio p_t. The strongest impact exhibit the forecast errors made in period $t-1$ and $t-2$. A revenue forecast error of 1 percentage point in each of these periods leads to change of almost 0.3 percentage points in the actual primary balance-GDP ratio. A revenue forecast error of 1 percentage point in period $t-3$ leads to a change of around 0.1 percentage points. The four-year ahead forecast error $f_{t|t-4}$ also has a small effect on the budget balance though the estimated coefficient is not statistically significant at common significance levels. In contrast, the estimated coefficient for $f_{t|t-0}$ is nearly zero, which means that the spring forecast for the current year is almost irrelevant for the budgetary outcome.

Interestingly, the estimated response of the primary balance-GDP ratio to the output gap is also close to zero. This indicates that the actual business cycle dynamics are already reflected in the forecast errors. The reason for this might be that forecasts are often made under the implicit or explicit assumption of a closed output gap (output gap of zero) in the medium run. Consequently, non-zero output gaps in these periods then directly result in an over- or underestimation of tax revenues. The estimated debt coefficient is slightly positive but not statistically distinguishable from zero. We thus find no strong evidence for consolidation policies of German states in response to past debt. The persistence coefficients are both sizeable and statistically significant, showing that serial correlation of the residuals is indeed an issue in the regression model given by equation (1).

3.2 Sensitivity analyses

We perform several robustness checks to test the sensitivity of our baseline results to alternative model specifications. First, we omit the output gap as explanatory variable (specification A2). As expected, this only marginally affects the estimation results. Second, we explore potential differences when modeling the residuals u_t as an AR(1) process and when simply including a lagged dependent variable on the right hand side of equation (1) to deal with serial correlation (specification A3 and A4, respectively). The specification with AR(1) errors again delivers results that are very close to our baseline specification.

Table 2: Baseline results and alternative specifications

	(A1) p_t 1976-2017	(A2) p_t 1976-2017	(A3) p_t 1976-2017	(A4) p_t 1976-2017	(A5) p_t 1976-2008
$f_{t\|t-0}$	-0.007	-0.036	0.088	-0.208	0.121
	(0.164)	(0.138)	(0.224)	(0.221)	(0.234)
$f_{t\|t-1}$	0.291**	0.214**	0.355***	0.512***	0.396***
	(0.120)	(0.085)	(0.117)	(0.142)	(0.114)
$f_{t\|t-2}$	0.265***	0.250***	0.307***	0.230***	0.278***
	(0.060)	(0.056)	(0.063)	(0.065)	(0.091)
$f_{t\|t-3}$	0.124**	0.119**	0.134**	-0.009	0.116*
	(0.052)	(0.046)	(0.063)	(0.090)	(0.059)
$f_{t\|t-4}$	0.083	0.098	0.036	-0.033	0.058
	(0.057)	(0.059)	(0.064)	(0.049)	(0.073)
g_t	-0.030		-0.057**	-0.074***	-0.023
	(0.026)		(0.023)	(0.025)	(0.047)
b_{t-1}	0.035	0.038	0.021	0.013	0.061
	(0.026)	(0.025)	(0.030)	(0.009)	(0.048)
α	-0.353	-0.412	-0.126	-0.121	-0.716
	(0.457)	(0.455)	(0.523)	(0.164)	(0.742)
ρ_1	1.143***	1.232***	0.704***		1.190***
	(0.201)	(0.154)	(0.088)		(0.278)
ρ_2	-0.494**	-0.569***			-0.484
	(0.231)	(0.186)			(0.333)
p_{t-1}				0.472***	
				(0.072)	
Obs.	42	42	42	42	33
Adj. R^2	0.867	0.866	0.846	0.840	0.856
AIC	-0.404		-0.298	-0.213	
SIC	0.145		0.204	0.283	

Notes: Robust standard errors are given in parentheses. See equation (1), (2), and main text for further details. ***/**/* indicates statistical significance at the 1%/5%/10% level. AIC: Akaike information criterion. SIC: Schwarz information criterion.

The specification with a lagged dependent variable also indicates a strong impact of the one-year ahead and two-years ahead forecast errors. In contrast to our baseline specification, we do not find a significant impact of the three-years ahead forecast errors while the impact of the one-year ahead error is more sizeable. Third, we check the temporal stability of our results. To do so, we compare our baseline results with the results of a shorter pre-crisis sample ranging from 1976 to 2008 (specification A5). The estimated coefficients are broadly similar to the baseline estimates, indicating that the impact of the forecast errors has not changed significantly over time and that our baseline results are not driven by extraordinary events subsequent to the financial crisis. Overall, we conclude from the sensitivity analyses that the findings from our baseline model are remarkably robust across alternative specifications and samples.

3.3 Cross-horizon mean error and asymmetric reactions

So far, our baseline specification has included all the individual forecast errors $f_{t|t-i}$ to investigate the importance of each forecast horizon $t-i$. In this subsection we consider instead the cross-horizon mean forecast error as explanatory variable. This allows us to quantify the impact of the average error across all forecast horizons concerning the tax revenues in a specific period t. In particular, we calculate $f^{04}_{t|t-i} = \frac{1}{5}\sum_{i=0}^{4} f_{t|t-i}$ and estimate

$$p_t = \alpha + \beta f^{04}_{t|t-i} + \gamma \mathbf{x}_t + \delta \mathbf{d}_t + u_t. \qquad (3)$$

The corresponding results are displayed in Table 3 (specification B1). The estimated coefficient for $f^{04}_{t|t-i}$ equals around 0.8, with a value of 1 being within the one-standard error band. When considering the pre-crisis sample 1976-2008 (specification B2), we find an even higher point estimate of around 0.9. These estimates show that the overwhelming part (around four-fifth) of the cross-horizon mean forecast error for a specific period ultimately translates into the final budget balance. They also suggest that revisions in revenue forecasts lead only to a minor degree to adjustments in the government's expenditure plans. To empirically support this argument, we additionally regress the expenditure-GDP ratio on the cross-horizon mean forecast error (see Appendix). We indeed find that the reaction of expenditures to the mean forecast error is very small and not statistically distinguishable from zero.[9]

Next, we have a closer look at the budget impact of the average error over the medium run horizons $t-i, i = 2, 3, 4$ versus the short run horizons $t-i, i = 0, 1$. For this specification we calculate $f^{24}_{t|t-i} = \frac{1}{3}\sum_{i=2}^{4} f_{t|t-i}$ and $f^{01}_{t|t-i} = \frac{1}{2}\sum_{i=0}^{1} f_{t|t-i}$ and include both as explanatory variables in our model (specification B3). We find a strong effect of the medium run mean forecast error on the primary balance-GDP ratio, with an estimated coefficient for $f^{24}_{t|t-i}$ of almost 0.5. Moreover, we find a slightly lower coefficient for $f^{01}_{t|t-i}$,

[9] These results are also in line with Chatagny and Soguel (2012). Based on a different model setup, they find that revenue forecast errors affect actual expenditures in a similar magnitude as actual revenues. This corroborates our finding that revenue forecast errors translate to a large extent into the budget balance and fits with our interpretation that expenditure plans are rarely adjusted according to revisions of tax revenues.

which is not statistically significant at common levels. This result again demonstrates the importance of the medium run forecasts for the final budgetary outcome.

Finally, we explore potential asymmetric reactions of the primary balance-GDP ratio to forecast errors. To do so, we consider a model specification that allows for different reactions to positive and negative cross-horizon mean forecast errors. This specification takes the form:

$$p_t = \alpha + \beta_1 f^{04pos}_{t|t-i} + \beta_2 f^{04neg}_{t|t-i} + \gamma \mathbf{x}_t + \delta \mathbf{d}_t + u_t. \qquad (4)$$

Our estimation results do not point to notable asymmetric reactions (specification B4). The difference between the reaction to positive and negative forecast errors is very minor and not statistically significant. Given our previous argument that German states only marginally engage in active fiscal policy in response to business cycle fluctuations, this result is not surprising. Nonetheless, it underlines the usefulness of the German states data for analyzing our research questions.

4 Forecast errors and debt accumulation

The regression results from the previous section show that not only the errors in the one-year ahead forecast but also in the medium run forecasts matter for the final budget balance. Given the (upward) bias of the medium run forecasts documented in Section 2.1, we now perform some back-of-the-envelope calculations to derive the impact of the forecast errors on the accumulation of debt. This exercise is meant to illustrate the link between forecast errors and the sustainability of public finances.

We assume that the debt stock B_t follows the law of motion

$$B_t = B_{t-1} + i_t B_{t-1} - P_t, \qquad (5)$$

where P_t denotes the primary balance and i_t denotes the implicit interest rate derived from the interest payments in period t and the previous period's end-of-period debt.[10] We then calculate the effect of the forecast errors on the primary balance using our baseline estimates from specification A1:

$$P^f_t = (\sum_{i=0}^{4} \hat{\beta}_i f_{t|t-i}) Y_t. \qquad (6)$$

[10]Note that the budget balance rather corresponds to net debt as a stock and that gross debt can be affected by stock-flow adjustments. To simplify matters, we assume stock-flow adjustments to be zero.

Table 3: Cross-horizon mean error and asymmetric reactions

	(B1) p_t 1976-2017	(B2) p_t 1976-2008	(B3) p_t 1976-2017	(B4) p_t 1976-2017
$f^{04}_{t\|t-i}$	0.809***	0.933***		
	(0.201)	(0.196)		
$f^{01}_{t\|t-i}$			0.427	
			(0.262)	
$f^{24}_{t\|t-i}$			0.450***	
			(0.108)	
$f^{04pos}_{t\|t-i}$				0.787**
				(0.289)
$f^{04neg}_{t\|t-i}$				0.819***
				(0.254)
g_t	-0.010	-0.037	-0.017	-0.009
	(0.020)	(0.056)	(0.031)	(0.021)
b_{t-1}	0.043	0.075	0.041	0.043
	(0.031)	(0.056)	(0.031)	(0.030)
α	-0.480	-0.863	-0.447	-0.479
	(0.549)	(0.871)	(0.551)	(0.564)
ρ_1	1.162***	1.184***	1.104***	1.166***
	(0.184)	(0.265)	(0.233)	(0.190)
ρ_2	-0.489**	-0.499	-0.433	-0.492**
	(0.224)	(0.307)	(0.278)	(0.234)
Obs.	42	33	42	42
Adj. R^2	0.857	0.847	0.854	0.853

Notes: Robust standard errors are given in parentheses. See equations (3) and (4) as well as main text for further details. ***/**/* indicates statistical significance at the 1%/5%/10% level.

Accordingly, the hypothetical primary balance without forecast errors is given by

$$P^*_t = P_t - P^f_t, \tag{7}$$

and the hypothetical debt stock without forecast errors is given by

$$B^*_t = B^*_{t-1} + i_t B^*_{t-1} - P^*_t. \tag{8}$$

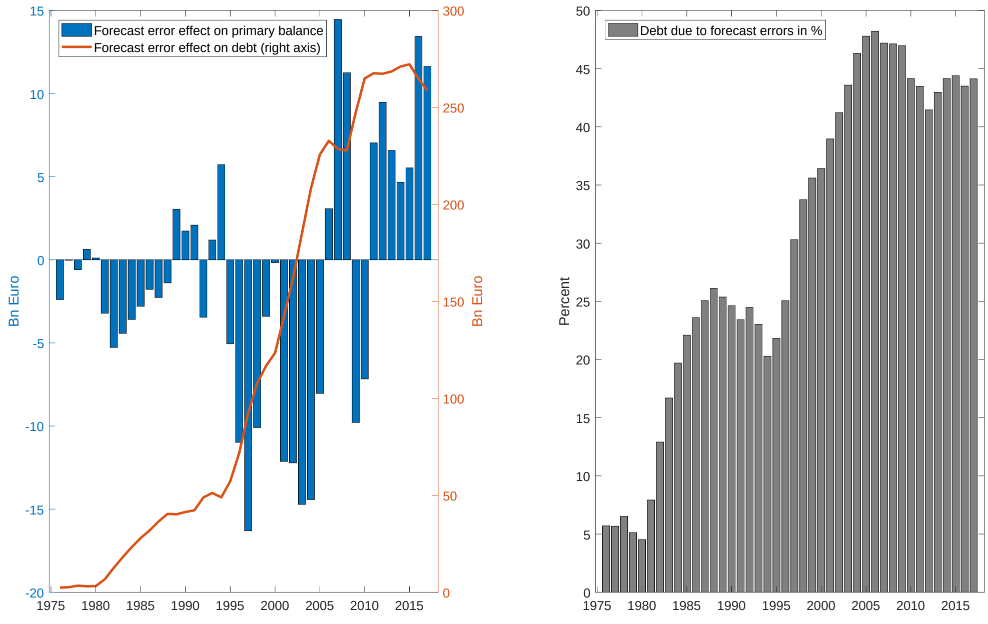
Finally, from the difference between (5) and (8) we obtain the impact of the errors on the accumulation of debt:

$$B^f_t = B_t - B^*_t. \tag{9}$$

In line with the estimated debt coefficient in specification A1, we do not consider a systematic response of German states to past debt levels. A significantly positive debt response would mitigate the impact of biased medium run forecasts on the accumulation of debt.

Figure 2 shows on the left hand side the calculated impact of the revenue forecast errors on the primary budget balance and debt over time. Particularly striking is the continuous negative effect on the primary budget balance from the mid '90s until the year 2005, which led to a strong increase in debt. From 2011 onwards, the forecast error effect on the primary budget balance is positive. Because of interest payments, however, the resulting error-based debt stock declines only slowly. The share of debt due to forecast errors in total debt of German states is plotted on the right hand side of Figure 2. We calculate that roughly 40 percent of total debt of German states results from forecasts that overestimated the actual revenues.

Figure 2: Forecast errors and debt accumulation



Notes: Left figure: Impact of revenue forecast errors on the primary budget balance and debt over time. Right figure: Debt due to forecast errors in percent of total debt.

5 Conclusions

Based on a data set for German states, our analysis has shown that even errors in several-year ahead revenue forecasts significantly affect the final budget balance. This suggests that expenditures get often binding once they are planned and therefore get only marginally adjusted over the planning period. There could be good reasons for doing so – a stable path of expenditures may be desirable from a political but also from an economic point of view. However, our findings highlight that, as a consequence of a low flexibility of expenditures, the accuracy of medium run forecasts becomes all the more important for the sustainability of public finances. To increase the benefits of multi-year fiscal planning, the results of this paper should encourage further research to improve the accuracy of forecasts for the medium run. Given the difficulty of this task, normative fiscal rules that incorporate a systematic reaction to past debt levels could help mitigate the risks of biased revenue projections.

Appendix

In this appendix, we present some additional results when regressing actual expenditures e_t (excluding interest rate payments and expressed in relation to nominal GDP) on tax revenue forecasts and forecast errors (Table A1).[11] Specification C1 shows an economically and statistically significant impact of the cross-horizon mean revenue forecast $r^{04}_{t|t-i} = \frac{1}{5}\sum_{i=0}^{4} r_{t|t-i}$ on expenditures. This is what one would expect given the previous results of specification B1. Specification C2 shows that the impact of the mean forecast error $f^{04}_{t|t-i}$ on expenditures is very small and not statistically distinguishable from zero. As discussed before, this suggests that revisions in revenue forecasts lead only to a minor degree to adjustments in the government's expenditure plans. Specification C3 resembles the specification in Chatagny and Soguel (2012) and shows that revenue forecast errors affect expenditures in a similar magnitude as actual revenues. Finally, specification C4 shows that expenditures significantly react to the mean revenue forecast but not to actual revenues. Note that specification C3 and C4 are just reformulations of specification C2. Thus, all coefficient estimates could also be directly calculated from the previous regression results.

[11] For the specifications with expenditures as dependent variable we assume the errors to follow an AR(1) process. The results are very similar when choosing AR(2) errors. Generally, a regression with expenditures on the left hand side is prone to simultaneous shifts in expenditures and revenues, for instance due to a change in the size of the government sector or federal structures. Such a regression is therefore more likely to be affected by omitted variables or structural instabilities than our baseline regression with the primary budget balance on the left hand side.

Table A1: Expenditures as dependent variable

	(C1) e_t 1976-2017	(C2) e_t 1976-2017	(C3) e_t 1976-2017	(C4) e_t 1976-2017
$r^{04}_{t\|t-i}$	0.554*	0.542		0.561*
	(0.301)	(0.441)		(0.295)
$f^{04}_{t\|t-i}$		-0.019	-0.561*	
		(0.255)	(0.295)	
r_t			0.542	-0.019
			(0.441)	(0.255)
g_t	-0.046	-0.045	-0.045	-0.045
	(0.039)	(0.036)	(0.036)	(0.036)
b_{t-1}	-0.044	-0.046	-0.046	-0.046
	(0.121)	(0.160)	(0.160)	(0.160)
α	8.160*	8.296	8.296	8.296
	(4.304)	(6.158)	(6.158)	(6.158)
ρ_1	0.873***	0.878***	0.878***	0.878***
	(0.187)	(0.258)	(0.258)	(0.258)
Obs.	42	42	42	42
Adj. R^2	0.880	0.876	0.876	0.876

Notes: Robust standard errors are given in parentheses. ***/**/* indicates statistical significance at the 1%/5%/10% level.

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