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Tax Revenue Forecast Errors: Wrong Predictions of the Tax Base or the Elasticity?

Abstract

In this paper, we disentangle tax revenue forecast errors into influences stemming from wrong macroeconomic assumptions and false predictions of the elasticities linking the tax base to its corresponding tax type. Across six tax types and the overall tax sum for Germany, we find a heterogeneous degree of relative importance of both sources. Whereas wrong macroeconomic assumptions matter most for profit-related taxes and the wage tax, false predictions of the elasticities mainly drive the forecast errors of the energy tax and the sales taxes. For the overall tax sum, more than two-third of the error can be attributed to wrong macroeconomic predictions and approximately one-third to false assumptions on the elasticity. Our results suggest that outsourcing the macroeconomic projections to an independent forecaster and methodological improvements can reduce tax revenue forecast errors.

JEL-Codes: H290, H680, H690.

Keywords: tax revenue forecasting, tax elasticity, unbiasedness, forecast errors.

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1. Introduction

Tax revenue forecasts are an essential input for fiscal policy planning in the short- and medium-term (Auerbach, 1999). If tax revenue forecasts are not systematically biased in any direction, they can serve as a guideline for future spending leeway and prevent governments to run into excessive public debts and deficits. Despite political economy arguments, biases in tax revenue estimates largely stem from wrong macroeconomic predictions. If the macroeconomic outlook changes or was assessed wrongly, this ultimately translates into false tax revenue predictions. However, not only the prediction of macroeconomic conditions itself leads to biased estimates on future tax revenues, but also wrong assessments of linkages across macroeconomic aggregates and tax revenues, namely, tax revenue elasticities. In this paper, we disentangle tax revenue forecast errors into these two sources of possible distortions for a variety of tax types and the overall tax sum.

The accuracy of overall tax revenue estimates has often been investigated for a wide range of countries in different setups (see, for a survey, Leal *et al.*, 2008). However, the consequences for the forecast accuracy of the interplay between macroeconomic assumptions and their transmission into tax revenue predictions is missing. Based on his own findings, Heinemann (2006) hypothesized that wrong budgetary forecasts are mainly driven by false macroeconomic growth projections and wrong assumptions on the tax elasticities. He, however, does not go deeper in this direction by disentangling both sources of errors. We take up this road and study the German case as tax revenue estimates there have a long tradition and receive a considerable media attention. Ademmer and Boysen-Hogrefe (2019) also contribute an interesting finding: tax revenue forecast errors in the medium-term considerably translate into the budget balance of German states, thus, overoptimistic forecasts drive total debt. Furthermore, Germany gives us a very interesting setup as tax revenue estimates are produced by an official board or working group that covers governmental agents as well as independent experts. Single tax revenue predictions are produced by each independent expert in advance and the final numbers are reached via a consensus across the working group's members. The macroeconomic outlook, however, is given by the governmental agents and is thus exogeneous to the working group. So in the end, the resulting forecast error of the working group is driven by the accuracy of the exogeneous macroeconomic assumptions and the translation of these figures into final tax estimates.

Our results indeed suggest that both error sources matter, with heterogeneous degrees across the tax types. For profit-related taxes as well as the wage tax, more than 90% of the explained forecast error can be attributed to wrong macroeconomic assumptions. The opposite holds true for the energy tax and sales taxes. 94% of the explained energy tax forecast error and two-third of the explained sales taxes error is attributed to a false assessment of the tax revenue elasticity with respect to its corresponding tax base. For the overall tax sum, 31% of the explained error can be attributed to the forecast error of the elasticity and 69% to the error of a wrong macroeconomic prediction.

Given our findings, we complement the existing literature for Germany in two ways. First, we investigate the channel of a rather methodological influence and formulate a statement on its absolute and relative importance compared to forecast errors stemming from macroeconomic projections. Second, we not only analyze the overall tax sum but rather broaden the picture and investigate the forecasting performance for the six largest taxes in Germany that account, on average, for 81% of total tax revenues in the last three decades. An early and in depth analysis on the accuracy of tax revenue forecasts in Germany is provided by Gebhardt (2001). For the period from 1970 to 2000, he attests the working group a high average short-term forecast accuracy (here: the running year) but cannot fully disentangle the forecast errors due to data restrictions. Büttner and Kauder (2015) find similar results for total tax revenues and the period running from 1971 to 2013. The forecasts for the current and the following year are, on average, unbiased, but forecast errors for gross domestic product (GDP) explain lots of the variation in total tax revenue forecast errors. The studies by Heinemann (2006) and Breuer (2015) put the spotlight on the medium-term performance of tax revenue estimates. Heinemann (2006) summarizes that revenue predictions are biased towards overoptimism, especially for forecast horizons longer than one year ahead. Breuer (2015) underpins the finding that medium-term tax projections are too optimistic, which is mainly described by forecast errors for GDP. Finally, Bischoff and Gohout (2010) find that total tax revenues for the states belonging to former Western Germany are generally not upward biased, but the overoptimism is negatively correlated with the incumbents' popularity and thus their chances of being reelected.

German tax revenue predictions have also been part of studies that exploit the international dimension of forecast accuracy and its determinants. A large part of the existing studies deal with political economy arguments (see, among others, Beetsma *et al.*, 2009, 2013; Cimadomo, 2016; Jochimsen and Lehmann, 2017; Strauch *et al.*, 2004). Büttner and Kauder (2010) instead explore how cross-country differences in the tax revenue forecasting process (for example, the length of the forecast horizon, the number of taxes predicted, and, more important, the overall independence of the preparation) correlate with the degree in forecast accuracy. Despite the large influence of wrong macroeconomic projections, they find that the degree in independence is positively associated with the forecast accuracy. It seems therefore reasonable to outsource the whole forecasting process to independent institutions, which has also been emphasized by Jonung and Larch (2006). We therefore compare the accuracy of macroeconomic projections from the working group with those of an independent institution in Germany that serve as input for the government. It turns out that the independent forecaster outperforms the predictions of the government, thus, the tax revenue forecast errors can, c.p., be reduced by fully outsourcing the macroeconomic projections to the already existing independent institution.

Our paper is structured as follows. In Section 2, we introduce the institutional framework in which German tax revenue forecasts operate. Section 3 outlines the theoretical considerations guiding our empirical strategy (Section 4). In Section 5, we present our main results, followed by the comparison of accuracy to the independent forecasting institution in Section 6. The last section concludes.

2. Institutional Setup

Since 1955, tax revenue forecasts in Germany are produced by the Working Party on Tax Revenue Estimates (WPTRE, in German: *Arbeitskreis Steuerschätzungen*). The Working Party acts as an advisory board for the Federal Ministry of Finance and grounded its acting on bylaws in the mid of 2017.[1] To ensure the independence, the Party consists of 27 governmental and non-governmental members: the Federal Ministry of Finance (head), the Federal Ministry for Economic Affairs and Energy, the five main Economic Research Institutes in Germany[2], the Federal Statistical Office, the German Central Bank, the German Council of Economic Experts, each of the 16 Federal Ministries of Finance, and the Association of German Cities.

The Working Party meets twice a year, namely in May and in November. In May, the forecasts are formulated for the current and the four upcoming years and serve as the basis for the budget draft of the following year and the annual update of the medium-term budget planning. The forecast in November comprises the current and the five upcoming years and serves as the final formulation of next year's tax revenues in the federal budget. The Working Party follows a bottom-up approach, meaning that each of the 32 single taxes (resp. tax groups)[3] is forecasted separately. At each forecasting date, eight members—the five Research Institutes, the German Central Bank, the German Council of Economic Experts, and the Federal Ministry of Finance—present their individual forecasts and a discussion takes place for each single tax (resp. tax groups) until a consensus is reached among all members.

Each individual forecast is calculated under two circumstances. Whereas the Federal Ministry of Finance allows each member to base their forecasts on their individual methodology, the macroeconomic projections (for example, the growth of nominal gross domestic product) are given by the political authority; this applies equally to all tax bases. Thus, each member has to base its tax revenue forecasts on the macroeconomic projections of the government. This is the main reason to let Büttner and Kauder (2010) state that German tax revenue forecasts are by no means fully independent. In general, the individual tax revenues are

[1] A detailed description of the Working Party on Tax Revenue Estimates can be found here: `https://www.bundesfinanzministerium.de/Content/EN/Standardartikel/Topics/Taxation/Articles/working-party-on-tax-revenue-estimates.html` (accessed on August 12, 2020).

[2] DIW: German Institute for Economic Research in Berlin; IfW: Kiel Institute for the World Economy; ifo: ifo Institute–Leibniz Institute for Economic Research at the University of Munich e.V.; RWI: RWI Leibniz Institute for Economic Research; IWH: Leibniz Institute for Economic Research Halle.

[3] A list containing the 32 taxes (resp. tax groups) can be found in Appendix A.

calculated according to the existing taxation law. However, planned tax law changes are estimated by the Federal Ministry of Finance and are included in the budgetary planning.

Not much information is available about the applied methodology of each Party member. Büttner and Kauder (2008) published a book that compares tax revenue forecast methodologies for a multitude of countries. According to their descriptions, the members of the Working Party on Tax Revenue Estimates mainly base their forecasts on *indirect* methods such as macroeconomic simulations or the application of tax elasticities. Macroeconomic simulations make usage of the existing tax law, tariffs and their connection to various tax bases. In contrast to microeconomic simulations, all functional forms are specified at the macroeconomic instead of the individual level. Elasticity methods are a common practice: based on historical data, an elasticity between a tax type and its corresponding tax base is estimated and applied for forecasting (Büttner and Kauder, 2008, 2010). Both methods can coincide, especially if the elasticity model is specified correctly. As the macroeconomic simulation postulates functional forms between a tax type and a tax base—given the current law and existing tax allowances—it implicitly models elasticities.

In the end, a consensus is reached among the party members. After the completion of a forecast meeting, the results are published to inform the interested public. The federal government uses the forecasts for its budget draft as well as its medium-term financial planning. The results are also the basis for the estimation of state-specific tax revenues and serve as a major indicator for many municipalities.

3. Theoretical Considerations

The Working Party on Tax Revenue Estimates in Germany typically focuses on a multitude of target series to forecast, ranging from $R = 32$ different taxes (resp. tax groups), y_t^r, to total tax revenues, $Y_t = \sum_{r=1}^{R} y_t^r$. Prior to the first release of the tax revenue figures for a specific year t, the WPTRE produces its forecasts, $\widehat{y}_{t|t-h}^r$ and $\widehat{Y}_{t|t-h}$, at different points in time with a forecast horizon of h years. After the release, the WPTRE's forecast errors, $\text{FE}_{h,t}^r = \widehat{y}_{t|t-h}^r - y_t^r$ and $\text{FE}_{h,t} = \widehat{Y}_{t|t-h} - Y_t$, can be calculated. A positive sign indicates an overestimation; the opposite represents an underestimation.

Assume that the Working Party is fully rational and tries to formulate an optimal forecast at $t - h$, given an information set Ω_{t-h}; this set comprises information on the different tax revenues such as the corresponding tax bases. If the WPTRE operates under a quadratic loss function, it tries to minimize the expected mean squared forecast error (Batchelor, 2007)

$$\mathcal{L}_h^r = \text{E}\left[\left(\widehat{y}_{t|t-h}^r - y_t^r\right)^2 |\Omega_{t-h}\right] . \tag{1}$$

The optimal forecast, $\widehat{y}^{*,r}_{t|t-h}$, is than given as the conditional expectation

$$\widehat{y}^{*,r}_{t|t-h} = \mathrm{E}\left[y^r_t|\Omega_{t-h}\right] \ . \tag{2}$$

This forecast, and thus the resulting forecast error, mainly depends on the information set. At time $t-h$, the WPTRE produces its forecast given that the prediction is a function of the information set: $\widehat{y}^r_{t|t-h} = f(\Omega_{t-h})$. According to the institutional setup described in Section 2, we can model the information set in much more detail. We distinguish between both exogenous and endogenous factors that the WPTRE faces by producing its forecasts.

The applied methodology (METHOD) of each Party Member can be treated as an endogenous factor. If research activities take place, each Party Member might adopt new methodologies over time. However, this endogenous factor might be superimposed by one exogenous factor: the final forecast of the Working Party is a consensus (CONS) among all members, thus, the member-specific forecast is weighted by its own bargaining power within the Party. As we have no further insights on the distribution of power within the Working Party, we assume the weights to be equally distributed. Also the composition (COMP) of the Working Party is exogenous and time-invariant for the time of our analysis. Since the basic estimations of the working party members are on the basis of the current tax law, planned tax law changes (LAW) need to be taken into account additionally. They are provided by the Federal Ministry of Finance and are exogenous for the party members.[4] The last exogenous factor is crucial for our analysis, namely the Federal Ministry's input of the tax base forecasts (BASE).

All these factors are part of the information set that the Working Party faces at each forecasting date. It reads as: $\Omega_{t-h} = \{\text{METHOD, CONS, COMP, LAW, BASE}\}$. The final forecast of the WPTRE therefore is a function of these factors and, thus, the forecast error is: $\mathrm{FE}^r_{h,t|\Omega_{t-h}} = \widehat{y}^r_{t|t-h,\Omega_{t-h}} - y^r_t$. In the following, we assume—as the tax base forecasts are given to the Working Party—that the published forecasts are produced by a member-weighted elasticity method; the consensus among the members leads to a final forecast that can be linked to the tax base input provided by the Federal Ministry for Economic Affairs and Energy. We also argue that this assumption is realistic from a forecaster's point of view that works in the field of public economics. As elasticities can be seen as central figures in this field, the forecaster might run a cross-check by calculating the elasticities after the production of the forecasts. If these resulting elasticities seem implausible and heavily deviate from any given anchor such as long-term averages, an adjustment of the forecasts might take place before the final publication. As already stated in the previous section, elasticity methods are a common practice among the party members. Thus, the final outcome of the discussion

[4]The estimation of planned tax law changes and the general tax estimation are executed by different sections of the Federal Ministry of Finance. Effects of planned tax law changes on macroeconomic figures are taken into account in the macroeconomic projection by the Federal Ministry for Economic Affairs and Energy.

within the party can be treated as an equally-weighted forecast based on member-specific elasticity estimates.

We use the standard tax revenue elasticity, $\varepsilon^r_{y,B}$, which links the development of tax r to the development of its specific tax base B. This elasticity is defined as the ratio between the growth of tax revenues and the growth of the corresponding tax base:

$$\varepsilon^r_{y,B} = \frac{dy^r}{dB} \cdot \frac{B}{y^r} \; . \tag{3}$$

We can easily calculate these ex-post elasticities based on the given tax and macroeconomic data. If we, instead, take an ex-ante stand, we can replace each component by its forecast:

$$\widehat{\varepsilon}^r_{y,B} = \frac{\widehat{y}^r}{\widehat{B}^{\text{ex},r}} \; . \tag{4}$$

As previously stated, the forecast for the tax base is given to the Working Party and is thus exogenous ($\widehat{B}^{\text{ex}}$) as the Working Party has no veto against this prediction. The revenue forecast for each tax is reached via a consensus among the members, thus, we can calculate the resulting and implicit elasticity based on the published forecasts. It is, however, obvious that the forecast error of the Working Party mainly depends on the forecast error of the tax base as well as a wrong specification of the elasticity, given the other factors influencing the outcome. In the following section, we elaborate more on how we implement these theoretical considerations empirically.

4. Empirical Strategy

4.1. Derivation of the Empirical Model

As stated in Section 3, the forecast of the Working Party and thus the forecast error for a specific horizon h depends on the underlying information set, $\text{FE}^r_{h,t|\Omega_{t-h}} = \widehat{y}^r_{t|t-h,\Omega_{t-h}} - y^r_t$. This expression in growth rates leads to the first, rather standard check on unbiasedness in the sense of Holden and Peel (1990), $\text{FE}^r_{h,t|\Omega_{t-h}} = c^r_h + \eta^r_{h,t}$, that is, the forecast error should not show any systematic positive or negative bias. If this is true, the horizon-specific constant, c^r_h, becomes zero. However, unbiasedness is not the only criterion a forecast should fulfill. Weak rationality is the second characteristic which is discussed in the literature. The idea behind this characteristic is to ask whether the forecaster incorporates all possible information available at the time the forecast is produced. We, therefore, rearrange the forecast error and transfer it to an empirical application in the sense of Mincer and Zarnowitz (1969): $y^r_t = -c^r_h + \alpha\widehat{y}^r_{t|t-h,\Omega_{t-h}} - \eta^r_{h,t}$. Now we substract the forecast from both sides of the equation, rearrange the equation and get: $\text{FE}^r_{h,t|\Omega_{t-h}} = c^r_h - (1-\alpha)\widehat{y}^r_{t|t-h,\Omega_{t-h}} + \eta^r_{h,t} = c^r_h + \beta\widehat{y}^r_{t|t-h,\Omega_{t-h}} + \eta^r_{h,t}$. If no systematic bias exists and the forecast error is not correlated with the forecast ($c^r_h = \beta = 0$), then the forecast fulfills the criteria of weak rationality. In this case, only the forecast itself plays a role in explaining the forecast error. There are, however, more information available at the time when the forecast is calculated. If all information are treated efficiently, then the forecast fulfills the criterion of strong rationality.

In our notation from Section 3, the forecast is a function of the available information set: $\widehat{y}^r_{t|t-h,\Omega_{t-h}} = f(\Omega_{t-h})$. Taking the previous argumentation, strong rationality reads as:

$$\mathrm{FE}^r_{h,t|\Omega_{t-h}} = c^r_h + f(\Omega_{t-h}) + \eta^r_{h,t} \ .$$

For simplicity, we assume the information set function to have a linear form, depending on the factors introduced in the previous section: $f(\text{METHOD, CONS, COMP, LAW, BASE})$ with each factor modelled by a function itself. As argued, each member of the Party can have its own methodological approach, that is also time-dependent and could change over the years. However, this individual approach is outweighted as the final forecast is reached via a consensus across the members. In fact, the methodology is time-invariant, with the exception that an implicit elasticity ($\widehat{\varepsilon}^r_{y,B}$) results from the final forecast. Thus, the tax revenue forecast error might depend on a wrong assessment of the elasticity. We therefore assume that the influence of the methodology can be expressed by the forecast error of the tax revenue elasticity: $\text{METHOD} = \mathrm{FE}^{\varepsilon}_{h,t}$.

The influence of reaching a consensus per tax is time-invariant and reads as: $\text{CONS} = \text{CONS}^r_h$. The same applies to the composition of the Working Party. It might be the case that all or a group of forecaster produce systematically higher or lower forecast errors for a specific tax, depending on the characteristics of the forecaster (for example, the priority of putting effort in developing better forecasting techniques for a specific tax). Thus, the influence of the composition on tax revenue forecast errors of the Working Party is time-invariant: $\text{COMP} = \text{COMP}^r_h$. The tax base forecasts, instead, are exogenous to the Working Party. As the party members have to take these forecasts from the Federal Ministry of Finance, wrong assessments on the development of the tax base are converted one-to-one into the tax revenue forecast errors. It might therefore be reasonable to think that the influence of the tax bases can be expressed as their forecast errors: $\text{BASE} = \mathrm{FE}^B_{h,t}$. Taking all these influences together, our empirical model reads as:

$$\mathrm{FE}^r_{h,t} = \beta_1 \mathrm{FE}^B_{h,t} + \beta_2 \mathrm{FE}^{\varepsilon}_{h,t} + a^r_h + u^r_{h,t} \ , \tag{5}$$

with a^r_h as the time-invariant characteristics of the forecast calculation and $u^r_{h,t}$ as the usual idiosyncratic error term. This is a standard panel fixed-effects representation and each of the models' parameters—for simplicity we apply the same notation for each model here—are estimated by standard OLS. The parameters' standard errors are robust and clustered at the horizon level.

4.2. Data Set

We examine forecasts in growth rates of the overall tax sum and the six largest taxes (resp. tax groups): wage tax, assessed income tax, business tax, corporate tax, energy tax and sales taxes.[5] Between 1991 and 2019 these six taxes contributed, on average, by 81% to the overall tax sum. All tax revenues are measured at the federal level.[6] We analyze the time-span between 1992 and 2019. However, we have to restrict that range whenever the data availability is limited. For that reason we focus on the first four forecasting horizons. The WPTRE meets twice a year: usually in spring and in fall.[7] We analyze the forecasts for the current and for the following year. In spring, the latest realized macroeconomic values are the ones for the fourth quarter of the previous year. In fall, the latest published macroeconomic values are on the second quarter of the ongoing year. Consequently, we use the notation of horizon $h = 0.5$ for a forecast for the current year t produced in fall of the current year and $h = 1.5$ for a forecast for the next year $t + 1$. Similarly, the forecast produced for the current year in spring of the current year corresponds to horizon $h = 1$ and $h = 2$ stands for a forecast for the next year.

There are missing values for the corporate tax estimations for the years 2002 and 2003 at the first two horizons and for the year 2003 at the third horizon. Regarding the realized values, there is a severe outlier for the corporate tax with a decline of more than 700% in the year 2002. We excluded that year from our analysis of the corporate tax.

Figure 1 shows the forecasted (dashed line) and realized growth rates (solid line) of our sample beginning with the first horizon ($t + 0.5$) and ending with the last horizon ($t + 2$). Already at first glance, it is obvious that the shorter the forecast horizon is, the smaller is the forecast error. One can neither spot any clear bias nor a tax that performs particularly bad except of the one very pronounced overestimation at the third horizon for the corporate tax. However, Section 5 will deal with these questions from an empirical stance. Furthermore, it deals with the question if we can assign the forecast errors, the differences between the dashed and the solid lines, to a wrong elasticity or a wrong tax base forecast.

The forecast errors for the underlying tax bases are calculated as the difference between the forecasts and their published values. The implicitly forecasted and realized elasticities of the taxes are calculated according to Equation (4). We assign the taxes to their most fitting tax base in an economic sense. So, nominal GDP is the assigned tax base for the overall tax sum, gross wages and salaries for the wage tax, corporate and investment income for the assessed income, the business and the corporate tax, nominal GDP for the energy tax and private consumption for the sales taxes.[8] These tax bases correspond with the information provided by Gebhardt (2001).

[5] Appendix A contains the data sources and the time spans for which the data are available.

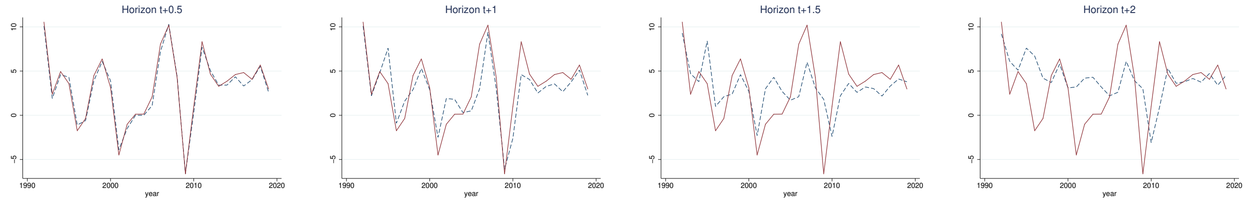
[6] For discussions on the German states, see Kauder *et al.* (2017) and Bischoff and Gohout (2010).

[7] In 2020, there was an additional third meeting during fall due to the Corona crisis.

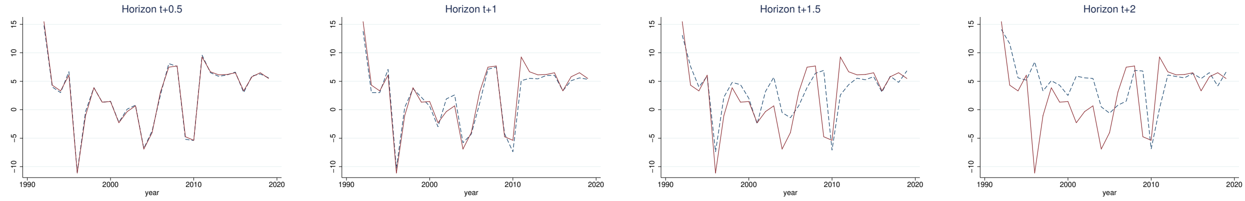
[8] There are two estimates of zero for the forecasted growth rate of the wages at the first horizon (2003 and 2005). Thus, the forecasted elasticities cannot be calculated at that horizon and are treated as missing.

Figure 1: Forecast performance for different taxes and horizons

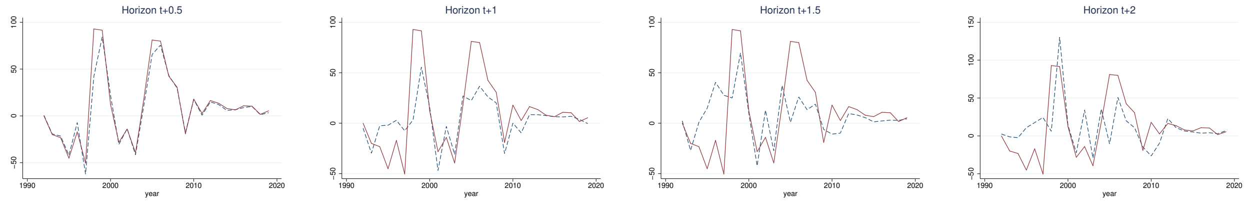
(a) Tax Sum



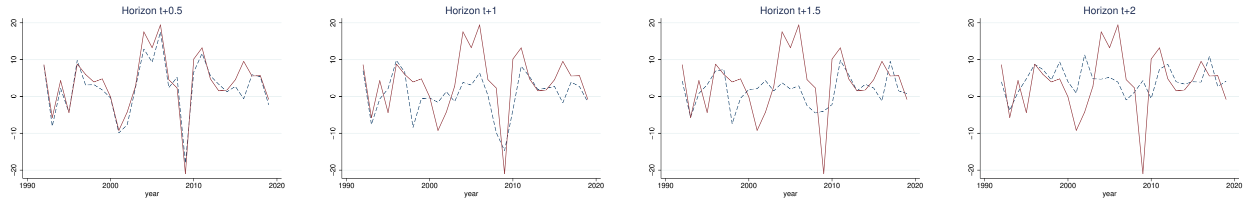
(b) Wage Tax



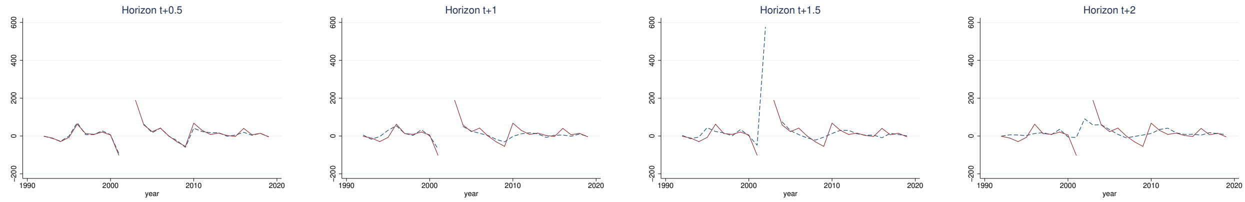
(c) Income Tax



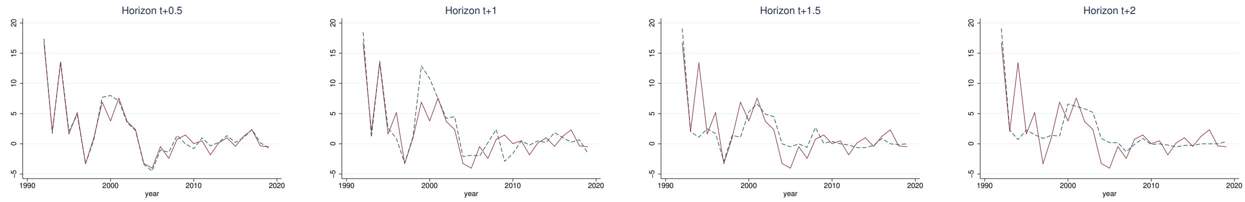
(d) Business Tax



(e) Corporate Tax



(f) Energy Tax



(g) Sales Taxes

Notes: The figures compare the forecasts (dashed line) with the realizations (solid line) of the growth rates (in %).

5. Results

5.1. Unbiasedness

To test for unbiasedness, we follow Section 4 and estimate the following panel model,

$$\mathrm{FE}^{i}_{h,t} = \alpha^{i}_{1} + u^{i}_{1,h,t} \; , \tag{6}$$

with i either representing tax revenues ($i = r$), the tax bases ($i = B$), or the elasticities ($i = \varepsilon$). Table 1 shows the results for the tax revenue forecast errors. The overall tax sum is not systematically biased in any direction, which is in line with Breuer (2015) and Büttner and Kauder (2015). The results are mixed for the individual taxes. Whereas we cannot detect any bias for the wage, corporate and energy tax, the income and business tax are underestimated; the sales taxes forecasts are on average too optimistic.

Table 1: Test on Unbiasedness of Tax Revenue Forecasts

	Tax Sum	Wage Tax	Income Tax	Business Tax	Corpor. Tax	Energy Tax	Sales Taxes
α^{r}_{1}	0.05	0.64	-2.98*	-1.55*	0.37	0.11	0.44***
	(0.30)	(0.53)	(1.56)	(0.82)	(0.82)	(0.17)	(0.17)
Obs.	112	112	112	112	105	112	112
R^2	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes: Clustered and robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Moreover, all key macroeconomic forecasts except corporate income show a bias (see Table 2). First of all, nominal GDP growth is overestimated by 0.41 percentage points in the sample period which is in line with the finding of Breuer (2015). Furthermore, the sum of gross wages and salaries as well as private consumption, which serve as tax bases for the wage tax and the sales taxes, are biased in opposite directions. Whereas wage growth is underestimated by -0.38 percentage points, the growth of private consumption is overestimated by 0.42 percentage points.

Table 2: Test on Unbiasedness of Tax Base Forecasts

	Nominal GDP	Wages	Corporate Income	Private Consump.
α^{B}_{1}	0.41**	-0.38***	1.34	0.42***
	(0.20)	(0.07)	(0.83)	(0.14)
Obs.	112	68	55	34
R^2	0.00	0.00	0.00	0.00

Notes: Clustered and robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Neither the elasticity of the wage tax with respect to gross wages and salaries nor the elasticity of the sales taxes with respect to private consumption are biased (see Table 3). Instead, the elasticity for the overall tax sum with respect to nominal GDP is underestimated by -0.12. Furthermore, the elasticities of two profit-related taxes are biased in the sample period. The elasticity of the business tax is overestimated by 1.42 and the elasticity of the corporate tax by 2.37. Furthermore, the elasticity of the energy tax is slightly underestimated. Our results for the elasticities cannot directly be compared to existing studies as the literature has not focused on this issue before. Breuer (2015), however, investigated the tax ratio (relation of tax sum to nominal GDP) and could not detect a bias after reunification; for the overall sample beginning in 1968 he finds an overestimation.

Table 3: Test on Unbiasedness of Elasticity Forecasts

	Tax Sum	Wage Tax	Income Tax	Business Tax	Corpor. Tax	Energy Tax	Sales Taxes
α_1^{ε}	-0.12***	-0.57	1.20	1.42***	2.37***	-0.12*	-0.02
	(0.04)	(0.77)	(1.03)	(0.42)	(0.85)	(0.07)	(0.03)
Obs.	112	66	55	55	55	112	34
R^2	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes: Clustered and robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

5.2. Weak Rationality

We continue with a test on weak rationality by estimating the following panel model,

$$\text{FE}_{h,t}^{i} = \alpha_2^i + \beta_1^i \widehat{y}_{h,t}^i + u_{2,h,t}^i \ , \tag{7}$$

with i again either representing tax revenues of each tax type ($i = r$), the tax bases ($i = B$), or the elasticities ($i = \varepsilon$); $\widehat{y}^i$ represents the forecast for the corresponding variable. As stated in Section 4, a weakly rational forecast implies $\alpha_2^i = \beta_1^i = 0$. A constant or a beta that significantly differs from zero can also be seen as a more robust indicator for bias detection than in the previous section on unbiasedness.

The results for the tax revenue forecasts are shown in Table 4. The forecasts for the overall tax sum, the wage tax, and the corporate tax are weakly rational according to our definition. In the other cases, either the constant (income tax, business tax and sales taxes) or both coefficients (energy tax) are non-zero. That means, the growth of the income (business) tax is underestimated by 3.41 (1.82) percentage points and the growth of the sales taxes are overestimated by 0.41 percentage points. Contrary, the energy tax is underestimated by 0.12 percentage points. Consequently, those forecasts do not fulfill weak rationality as defined in Section 4. The values for the R^2 are also very low. Compared to existing studies, our results for the overall tax sum are in line with Breuer (2015).

Table 4: Test on Weak Rationality of Tax Revenue Forecasts

	Tax Sum	Wage Tax	Income Tax	Business Tax	Corpor. Tax	Energy Tax	Sales Taxes
α_2^r	-0.19	0.48	-3.41*	-1.82***	1.85	-0.22*	0.41**
	(0.30)	(0.29)	(1.09)	(0.27)	(1.07)	(0.09)	(0.09)
β_1^r	0.07	0.05	0.06	0.12	-0.17	0.15**	0.01
	(0.09)	(0.09)	(0.15)	(0.12)	(0.12)	(0.04)	(0.02)
Obs.	112	112	112	112	105	112	112
R^2	0.01	0.01	0.00	0.02	0.02	0.08	0.00

Notes: Clustered and robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The results for the macroeconomic projections are mixed (see Table 5). While the forecasts for nominal GDP are weakly rational, the forecasts for gross salaries and wages, corporate and investment income and for private consumption are not. Growth of gross salaries and wages as well as of private consumption are underestimated by 1.08 resp. 1.78 percentage points and the corporate and investment income is overestimated by 1.15 percentage points. While the explanatory power of the forecast for corporate investment income and a constant remains very low for the variation of its forecast error, the opposite is true for private consumption. There, 45% of the variance of the forecast error can be explained by our model for weak rationality. Its large explanatory power supports our finding that the forecasts for private consumption are not weakly rational. Breuer (2015) also finds that nominal GDP forecasts are weakly rational.

Table 5: Test on Weak Rationality of Tax Base Forecasts

	Nominal GDP	Wages	Corporate Income	Private Consump.
α_2^B	-0.41	-1.08*	1.15**	-1.78*
	(0.44)	(0.45)	(0.32)	(0.58)
β_1^B	0.25	0.27	0.06	0.70**
	(0.13)	(0.18)	(0.10)	(0.19)
Obs.	112	68	55	34
R^2	0.08	0.10	0.01	0.45

Notes: Clustered and robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Regarding the forecasted tax elasticities, the wage tax elasticity as well as the elasticities for the profit related taxes, which are income tax, business tax and corporate tax, are not weakly rational (see Table 6). Furthermore, the elasticity forecasts of the profit-related taxes and a constant explain between 46%, 52% and 56% of the variation of their forecast error. Again, this large explanatory power of a constant and the forecast support our finding of a biased forecast for each of the profit-related taxes. The wrong forecast for the elasticity by itself could be responsible for the complete tax forecast errors.

Table 6: Test on Weak Rationality of Elasticity Forecasts

	Tax Sum	Wage Tax	Income Tax	Business Tax	Corpor. Tax	Energy Tax	Sales Taxes
α_2^ε	-0.35*	-3.21*	-1.75***	-0.21	-1.79**	-0.08	-0.60
	(0.12)	(1.18)	(0.14)	(0.19)	(0.40)	(0.05)	(0.27)
β_1^ε	0.25	2.36	0.99***	1.14***	1.15***	-0.07	0.49
	(0.13)	(1.06)	(0.05)	(0.14)	(0.11)	(0.09)	(0.23)
Obs.	112	66	55	55	55	112	34
R^2	0.06	0.19	0.56	0.46	0.52	0.00	0.21

Notes: Clustered and robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

5.3. Driving Forces of Forecast Errors

Finally, we ask whether the forecast errors for the tax bases, the elasticities or both explain the errors of the tax revenue forecasts and how much both components contribute to the explained variation in these errors.[9] For this reason, we estimate the following panel model already introduced in Equation (5):

$$\mathrm{FE}^r_{h,t} = \beta^r_2 \mathrm{FE}^B_{h,t} + \beta^r_3 \mathrm{FE}^\varepsilon_{h,t} + \alpha^r_3 + u^r_{3,h,t} \ .$$

If the tax forecast error can neither be traced back to the forecast error of the tax base nor the elasticity, this reads as $\beta^r_2 = \beta^r_3 = 0$ in our model. Besides, this implies a low value for the R^2. A large value for R^2 means that the forecast error of the tax can be explained to a high degree by the forecast error of the tax base, the forecast error of the elasticity and a constant. Ideally, these variables should have no explanatory power at all as would be indicated by values of the variables, that are statistically not different from zero. A significant constant could be interpreted as biasedness that cannot be assigned to the tax base and the elasticity while controlling for effects of the forecast error of the tax base and the forecast error of the elasticity.

The upper panel of Table 7 shows the results of the error-explanation-estimation. The overall tax forecast error is strongly determined by the forecast errors of both its tax base and its elasticity. A forecast error of one percentage point for the growth forecast for nominal GDP results in a forecast error of 1.15 percentage points for the growth forecast for the overall tax sum. If the elasticity is over-/ underestimated by one, this translates, c.p., to a forecast error of 1.45 percentage points. In combination with the constant, 81% of the variation in tax forecast errors is explained. Also, most of the analyzed individual tax forecast errors can be traced back to its tax base and/ or its linking elasticity. So, the forecast error of the wage tax is determined by the forecast error of the wages and of the linking elasticity, that is, the elasticity of the wage tax with respect to the sum of gross wages and salaries.

[9] To prevent running into issues of multicollinearity, Appendix A contains the correlation coefficients between both forecast errors. There is no indication that our estimation results are blurred by a high correlation across the regressors.

A forecast error in wage growth of one percentage points leads to a forecast error of 1.90 percentage points of the wage tax. An elasticity forecast error of one increases the forecast error by 0.04 percentage points. In addition with the constant, this covers 67% of the wage tax forecast error's variation.

Table 7: Origin of the Tax Forecast Error and Relative Explanatory Power

	Tax Sum	Wage Tax	Income Tax	Business Tax	Corpor. Tax	Energy Tax	Sales Taxes
β_2^r	1.15***	1.90***	1.38**	0.69*	2.65**	0.28*	0.75***
	(0.09)	(0.10)	(0.38)	(0.27)	(0.62)	(0.09)	(0.10)
β_3^r	1.45***	0.04**	-0.24	-0.01	0.18*	1.46***	2.47***
	(0.07)	(0.01)	(0.14)	(0.12)	(0.06)	(0.11)	(0.18)
α_3^r	-0.26***	0.81***	-9.07***	-2.72***	-6.73***	0.17**	0.08
	(0.04)	(0.04)	(0.36)	(0.19)	(0.87)	(0.05)	(0.05)
Obs.	112	66	55	55	55	112	34
R^2	0.81	0.67	0.24	0.31	0.42	0.44	0.84
				Relative Explanatory Power			
FE^B	69%	93%	99%	100%	97%	6%	35%
FE^ε	31%	7%	1%	0%	3%	94%	65%

Notes: Clustered and robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The income tax forecast error can be explained by the forecast error of the profits but not significantly by the elasticity. An over-/ underestimation of the growth rate of corporate and investment income results in a forecast error of 1.38 percentage points of the growth of the assessed income tax. The relative low value for the R^2 of 24% reveals that there must be much more to the picture of the income tax forecast errors than simply a wrong prediction of the tax base. As for all profit-related taxes (income tax, business tax and corporate tax), the proper estimation of the assessment timeline might be another source of forecast error irrespective of the size and dynamics of the profits themselves. Gebhardt (2001) points to this source of forecast error. We, however, cannot investigate this channel as we have no access to the assessment timelines of the past. The forecast error of the business tax can weakly be explained by the forecast errors of its tax base but not by its elasticity. Consequently, the explanation of the variance of the forecast error of our model is just 31%. The forecast error of the corporate tax is significantly influenced by the forecast error of corporate and investment income and only weakly by the elasticity. If the corporate income growth exhibits a forecast error of one percentage point, this results in a forecast error of 2.65 percentage points of the corporate tax; a wrong prediction of the elasticity results in a forecast error of 0.18 percentage points. In combination with the constant, 42% of the variance of the forecast error of the corporate tax can be explained.

The forecast error of the energy tax is strongly determined by the forecast error of its elasticity and by a much weaker extent by its tax base. An over-/ underestimation of the elasticity of magnitude one increases the forecast error of the growth rate of the energy tax by 1.46 percentage points. Adding the constant, this leads to an R^2 of 44%. For sales taxes, 84% of the variation of the forecast error can be explained by the forecast errors of private consumption and the linking elasticity, which are both highly significant. So, a forecast error for the growth rate of private consumption of one percentage point leads to a forecast error of the growth rate of the sales taxes by 0.75 percentage points. A forecast error of the elasticity of one results in a forecast error of 2.47 percentage points of the growth rate of the sales taxes.

The analysis of the estimation results indicates only whether the forecast errors of the tax base or the elasticity are significant drivers of the tax forecast error. An immediately adjacent question is: How much does each of those two factors explain the tax forecast error? Or different: Are the tax forecast errors more driven by wrong predictions of the tax base or the elasticity? A mere look at the coefficients only reveals the influence of a standardized amount of the forecast error of the tax or the elasticity. It does not yet reveal how much it contributes to the overall magnitude of the tax forecast error. A helpful instrument to investigate how much both sources contribute to the tax forecast error is the squared semi-partial correlation coefficient.[10] It shows how much the R^2 changes when a coefficient is not included into the regression. Hence, we can interpret the squared semi-partial correlation coefficient of a variable as the additional explanatory power that is supplied by this additional variable. We put the squared semi-partial correlation coefficients of the tax base and the elasticity in relation to each other such that they sum up to one. Hence, the values in the lower panel of Table 7 illustrate which share of the R^2 that is explained by the tax base forecast error and the elasticity forecast error can be attributed to each of them. We call this the relative explanatory power; Appendix B contains the absolute values.

For the overall tax sum, 69% of the explanatory power can be assigned to forecast errors of nominal GDP. This means the forecast error of nominal GDP had approximately twice as much influence on the tax forecast error variation than the elasticity in our sample period. Regarding the wage tax, we get an even clearer picture: 93% are attributed to the forecast error of the wages and only a small share to the elasticity. When looking at the profit-related taxes, nearly all the share is assigned to the forecast error of the corporate and investment income. However, the R^2 of the estimations are rather low compared to the other taxes.[11] As mentioned before, these are assessed taxes. The assessment timeline might complicate the tax forecasts (Gebhardt, 2001). A bad estimate for the assessment timeline can drive the forecast error of the tax forecast while not influencing the forecast error of the tax base or of the elasticity. For the energy tax, the picture is turned upside down. 94% of the share can be assigned to the forecast error of the elasticity. Again, this result is not surprising when looking at the estimation results. For the sales taxes we observe the largest value for

[10] The semi-partial correlation of x and y, when holding z constant for y is defined as $r_{x(y.z)} = \frac{r_{xy} - r_{xz} r_{yz}}{\sqrt{1 - r_{yz}^2}}$, where the correlation between two variables i and j is defined as r_{ij}.

[11] This can also be seen in their low values for the explanatory power in Table B1.

the R^2. Both, the tax base and the elasticity, were significant although to a different degree. When looking at the squared semi-partial correlation coefficients, we get a clearer picture regarding their importance. 65% of the variance of the tax forecast error can be explained by the elasticity. Only 35% can be attributed to the forecast error of private consumption.

Overall, we find heterogeneous influence across the tax types which source of influence matters most for the tax forecast errors. Thus, less biased future tax revenue forecasts might be either achieved by more precise macroeconomic projections that are an exogenous input for the Working Party, methodological improvements or both. Whereas we stick to the methodological issue in the conclusion to this paper, we compare the accuracy of the government's macroeconomic forecasts to the performance of an independent institution in the following.

6. The Independent Forecaster

According to Lehmann and Wollmershäuser (2020) and Büttner and Kauder (2010) independent institutions publish better forecasts than the government. Even more specific, the macroeconomic projections of the German government for nominal GDP are outperformed by the forecasts of the Joint Economic Forecast (JEF) according to Lehmann and Wollmershäuser (2020). The JEF is a biannual consensus forecast of Germany's main Economic Research Institutes, which serves as the central input for the government's own macroeconomic projections. Moreover, the legal position of the JEF tremendously changed in 2017 as the German Federal Government finally implemented the Two-Pack Regulation No. 473/2013 of the European Parliament and the Council of the European Union. This regulation prescribes that national budgetary processes shall be enhanced or produced by an independent body or institution. An ordinance that came into effect on July 1, 2018 appointed the JEF to be the independent body that assesses and confirms the government's macroeconomic projections. Given the existent literature, one can suspect the JEF might also outperform the WPTRE in its tax forecasts. Contrary to the WPTRE forecasts, which is based on accrual accounting just as the government's budget, the tax forecasts of the JEF are in terms of the System of National Accounts (SNA). That means, they cannot be compared to each other. Therefore, we compare the forecasts for the tax bases since a better tax base forecast should, c.p., result in a better tax revenue forecast. Büttner and Kauder (2010) argue in quite the same direction that better tax base forecasts should lead to better revenue predictions of various tax types and thus the overall tax sum. Breuer (2015) also suspects the WPTRE would produce better forecasts by using the macroeconomic projections of the JEF. We investigate these claims in the following and begin our investigation with a simple comparison of the forecast errors as well as the forecasts themselves and proceed with an analysis on statistical significance of the forecast deviations between the two institutions.

Table 8 presents the mean absolute forecast errors, $\text{MAFE}^{j,B} = 1/T \sum_T (|\text{FE}^{j,B}|)$ with $j = \text{JEF}, \text{GOV}$, and the mean absolute forecast deviation of the forecasts, $\text{MAFD}^B = 1/T \sum_T (|\widehat{y}^{B,\text{JEF}} - \widehat{y}^{B,\text{GOV}}|)$. We can confirm the finding of Lehmann and Wollmershäuser (2020) that the MAFE for nominal GDP by the JEF (1.14 percentage points) is smaller than the one by the government (1.19 percentage points). We observe a similar picture for the wage and private consumption forecasts, where the JEF outperforms the government by 0.07 and 0.10 percentage points, respectively. Only for the corporate and investment income, the forecasts by the government perform better than the ones by the JEF; the MAFE of the government is 0.18 percentage points smaller.

Table 8: Forecast Performance and Deviation

	Nominal GDP	Wages	Corporate Income	Private Consump.
MAFE^{GOV}	1.19	0.97	4.14	0.58
MAFE^{JEF}	1.14	0.90	4.32	0.48
MAFD	0.28	0.30	1.26	0.29
Obs.	105	68	55	34

Notes: The errors and the deviation are calculated for all four forecast horizons and are displayed in percentage points. The period under investigation runs from 1992-2019 for GDP. For the remaining tax bases it runs from 2001-2019 for the first two horizons and 2002-2019 for the last two horizons.

Instead of investigating the forecast errors, the mean absolute forecast deviation directly compares the growth forecasts of both institutions with each other. For nominal GDP, wages and private consumption, this deviation is around 0.30 percentage points. For corporate and investment income, the most volatile tax base, it is 1.26 percentage points. However, the absolute values give no information on whether and in which direction the government systematically deviates, on average, from the forecasts of the JEF. To test this, we run the following panel regression:

$$\widehat{y}_{h,t}^{B,\text{GOV}} - \widehat{y}_{h,t}^{B,\text{JEF}} = \text{DEV}_{h,t}^{B} = \alpha_4^B + u_{4,h,t}^B \,.$$

The results to this estimation are displayed in Table 9. The forecasts for private consumption by the government are 0.21 percentage points larger than the ones by the JEF. For the remaining tax bases, the government's forecasts do not seem to significantly deviate from the JEF's predictions; however, the average deviations are, with the exception of nominal GDP, not small at all. In Table 2 in Section 5, we observed an overestimation of 0.42 percentage points for private consumption in the government forecasts. Table 9 shows that the forecasts for private consumption by the JEF are on average 0.21 percentage points smaller. Consequently, using the JEF instead of the government forecast for private consumption would, c.p., remove or at least reduce the bias for this variable. Therefore, the bias for the sales taxes (see Table 1) should vanish or at least shrink.

Table 9: Test on Systematic Forecast Deviations

	Nominal GDP	Wages	Corporate Income	Private Consump.
α_4^B	-0.03	-0.11	0.18	0.21***
	(0.03)	(0.08)	(0.45)	(0.08)
Obs.	105	68	55	34
R^2	0.00	0.00	0.00	0.00

Notes: Clustered and robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Despite the fact that the government does not seem to systematically deviate—with the exception of private consumption—from the JEF, the deviations are quite large as shown in Table 8. These deviations might be triggered by an informational advantage of the government compared to the JEF. Usually, the government publishes its macroeconomic forecasts one or two weeks after the JEF publications. If the government incorporates new information effectively and thus deviates from the JEF, the precision of the government's forecasts should increase. Frankel and Schreger (2016) suggest to run the following regression:

$$\text{FE}_{h,t}^{B,\text{GOV}} = \alpha_5^B + \beta_4^B \text{DEV}_{h,t}^B + u_{5,h,t}^B \,. \tag{8}$$

Table 10 shows the corresponding estimation results. We indeed find that the government's forecast errors increase by the deviation from the independent forecaster as the positive β_4^B coefficients suggest. However, the effect is only statistical significant for nominal GDP and private consumption. The informational advantage the government possibly faces does not result in a higher accuracy of their macroeconomic projections. Rather the opposite holds true as the accuracy worsens, underpinning the larger overall absolute deviations. Furthermore, all tax base forecasts show systematic overall biases readily observable by the estimated constant terms α_5^B.

Table 10: Test on Informational Advantage of the Government

	Nominal GDP	Wages	Corporate Income	Private Consump.
α_5^B	0.37***	-0.32***	1.27*	0.77***
	(0.14)	(0.07)	(0.77)	(0.27)
β_4^B	0.77*	0.50	0.36	0.27*
	(0.46)	(0.45)	(0.41)	(0.16)
Obs.	105	68	55	34
R^2	0.04	0.04	0.02	0.34

Notes: Clustered and robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Altogether, we can support the hypothesis that the independent forecaster JEF can improve the tax forecasts, especially through the channel of more accurate macroeconomic projections. We find a significant improvement for nominal GDP and private consumption as tax bases. For the other two tax bases, the JEF forecasts are at least as good or better than the forecast by the government despite the information advantage of one or two weeks when it publishes its forecast. In the end we can ask why the government produces macroeconomic forecasts at all. The forecasts can be done at least as good by the independent institution. Moreover, according to the fiscal rules in the EU, the government forecast needs to be evaluated or even produced by an independent institution. Regarding our findings, replacing the government forecast with the JEF forecast would increase the accuracy and, on top, save resources that are used to produce the government's tax base forecasts.

7. Conclusion

This paper disentangles tax revenue forecast errors into two major sources: a wrong assessment of the macroeconomic outlook and a false prediction of the elasticity linking the tax base to its corresponding tax type. The analysis for six major tax types and the overall tax sum of Germany reveals that both sources matter for biases in tax revenue forecasts. However, we observe a heterogeneous degree of relative importance of both sources across tax types. Whereas more than 90% of the explained forecast error of the profit-related taxes (income tax, business tax, corporate tax) as well as the wage tax can be attributed to wrong macroeconomic assumptions, the opposite holds true for the two remaining taxes. Here, 94% (energy tax) or two-third (sales taxes) of the explained revenue forecast errors can be traced back to wrong assumptions on the linking elasticity. For the overall tax sum, 69% of the error can be attributed to wrong macroeconomic predictions and 31% to false assumptions on the elasticity. Especially the errors due to wrong macroeconomic projections can be mitigated according to our results. The comparison of the government's macroeconomic projections with those of an independent forecasting institution reveal that the independent forecaster produces better forecasts for nominal GDP and private consumption and at least as good predictions for gross wages and corporate income.

Our results give rise to improvements of the underlying tax revenue forecasting process that in the end might go hand in hand with even more precise forecasts. First, the macroeconomic projections should be fully outsourced to the independent institution. According to our results, this would reduce the bias introduced by the first source and might also save resources within the ministries that are used to produce the macroeconomic forecasts. Second, it is also likely that methodological improvements reduce future tax revenue forecast errors. Whereas the academic literature on macroeconomic forecasting, and here especially GDP, is flourishing, only a handful of newer articles exist that transfer modern forecasting techniques to issues of fiscal forecasting (see, for example, Asimakopoulos *et al.*, 2020). Dynamic factor models or mixed-frequency vector autoregressions are the workhorses in applied macroeconomic forecasting and have proven to outperform other techniques. Furthermore, new and larger data sets can be explored to further improve existing techniques such as elasticity methods. In the end, there is room for improvement to reduce forecast errors so that the necessity of tax revenues to serve as guidelines for future expenditures is strengthened, preventing governments to run into excessive public debts.

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A. Details on the Applied Data

A.1. List of Taxes (resp. Tax Groups) Forecasted by the Working Party on Tax Revenue Estimates

- Wage tax *(Lohnsteuer)*
- Assessed income tax *(Veranlagte Einkommensteuer)*
- Not assessed income tax *(Nicht veranlagte Steuern vom Ertrag)*
- Withholding tax *(Abgeltungsteuer)*
- Corporate tax *(Körperschaftsteuer)*
- Sales taxes *(Steuern vom Umsatz)*
- Wealth tax *(Vermögensteuer)*
- Inheritance tax *(Erbschaftsteuer)*
- Land transfer tax *(Grunderwerbsteuer)*
- Racebetting and lottery tax *(Rennwett- und Lotteriesteuer)*
- Fireprevention tax *(Feuerschutzsteuer)*
- Beer tax *(Biersteuer)*
- Other State taxes *(sonstige Ländersteuern)*
- Business tax *(Gewerbesteuer)*
- Land tax A *(Grundsteuer A)*
- Land tax B *(Grundsteuer B)*
- Other community taxes *(Sonstige Gemeindesteuern)*
- Energy tax *(Energiesteuer)*
- Tobacco tax *(Tabaksteuer)*
- Alcohol tax *(Alkoholsteuer)*
- Alcopop tax *(Alkopopsteuer)*
- Sparkling wine tax *(Schaumweinsteuer)*
- Intermediate product tax *(Zwischenerzeugnissteuer)*

- Coffee tax *(Kaffeesteuer)*
- Insurance tax *(Versicherungsteuer)*
- Electricity tax *(Stromsteuer)*
- Motor vehicle tax *(Kraftfahrzeugsteuer)*
- Air traffic tax *(Luftverkehrsteuer)*
- Nuclear fuel tax *(Kernbrennstoffsteuer)*
- Solidarity surcharge *(Solidaritätszuschlag)*
- Lump-sum import duties *(Pauschalierte Einfuhrabgaben)*
- Other federal taxes *(Sonstige Bundessteuern)*

A.2. Data Sources

- Tax revenue forecasts: press releases of the Federal Ministry of Finance, biannual reports on the tax forecasts in the periodical *ifo Schnelldienst*
- Macroeconomic projections of the Federal Ministry for Economic Affairs and Energy: biannual reports on the tax forecasts by the the Federal Ministry of Finance in their monthly report, Working Party on Tax Revenue Estimates
- Projections of the Joint Economic Forecast: reports published in the periodical *ifo Schnelldienst*
- Realized tax revenues: Federal Ministry of Finance
- Realized macroeconomic figures: Federal Statistical Office of Germany (vintage: Autumn 2020)

A.3. Data Availability

Table A1: Sample length of the WPTRE's and the government's forecasts

Horizon	Taxes (sum & types)	Nominal GDP	Wages	Corporate Income	Private Consumption
$t + 0.5$	1992-2019	1992-2019	2003-2019	2006-2019	2011-2019
$t + 1$	1992-2019	1992-2019	2003-2019	2006-2019	2011-2019
$t + 1.5$	1992-2019	1992-2019	2003-2019	2006-2019	2012-2019
$t + 2$	1992-2019	1992-2019	2003-2019	2007-2019	2012-2019

Table A2: Sample length of the JEF's forecasts

Horizon	Nominal GDP	Wages	Corporate Income	Private Consumption
$t + 0.5$	1992-2019	2001-2019	2001-2019	2001-2019
$t + 1$	1992-2019	2001-2019	2001-2019	2001-2019
$t + 1.5$	1992-2019	2002-2019	2002-2019	2002-2019
$t + 2$	1992-2019	2002-2019	2002-2019	2002-2019

A.4. Correlation Across Forecast Errors

Table A3: Correlation Across FE^B and FE^ε

	Tax Sum	Wage Tax	Income Tax	Business Tax	Corpor. Tax	Energy Tax	Sales Taxes
Corr.	0.24	-0.10	0.25	0.15	0.07	-0.13	-0.53
Obs.	112	68	55	55	55	112	34

B. Absolute Explanatory Power

Table B1: Squared Semi-Partial Correlation Coefficients – WPTRE

	Tax Sum	Wage Tax	Income Tax	Business Tax	Corpor. Tax	Energy Tax	Sales Taxes
FE^B	0.43	0.65	0.24	0.30	0.39	0.03	0.43
FE^ε	0.19	0.05	0.00	0.00	0.01	0.43	0.80