

Janeba, Eckhard; Köhler, Felix; Rostam-Afschar, Davud; Steger, Paul

**Conference Paper**

## The Fiscal and Economic Effects of the Biontech Shock

Beiträge zur Jahrestagung des Vereins für Socialpolitik 2025: Revival of Industrial Policy

**Provided in Cooperation with:**

Verein für Socialpolitik / German Economic Association

*Suggested Citation:* Janeba, Eckhard; Köhler, Felix; Rostam-Afschar, Davud; Steger, Paul (2025) : The Fiscal and Economic Effects of the Biontech Shock, Beiträge zur Jahrestagung des Vereins für Socialpolitik 2025: Revival of Industrial Policy, ZBW - Leibniz Information Centre for Economics, Kiel, Hamburg

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# The Fiscal and Economic Effects of the Biontech Shock

Eckhard Janeba, Felix Köhler, Davud Rostam-Afschar, Paul Steger\*

February 27, 2025

## Abstract

We study the expenditure and tax responses to municipal revenue shocks in Germany, leveraging quasi-experimental variation in tax revenues due to Biontech’s breakthrough in vaccine development against Sars-CoV-2. Discretionary spending does not adjust significantly, but treated municipalities repay outstanding debt, build up their capital reserves, and mechanically increase their contribution to the fiscal equalization system. Municipalities cut local business and property taxes, but we find no evidence on increased firm activity. The tax cuts align with municipalities’ ex ante expectation that the tax revenue shock is permanent, which later turned out to be transitory instead and subsequently forced them to revert most tax cuts within four years after the shock.

**Keywords:** Local Tax Policy, Municipal Revenue Shock, Public Investment, Government Spending

**JEL Classification:** E62, H71, H72, H73, H77, R12, R51

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We thank Johannes Kochems (discussant) as well as participants at the 11th Annual Mannheim Taxation Conference for their valuable comments. Rostam-Afschar is grateful to the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – Project-ID 403041268 – TRR 266 Accounting for Transparency for financial support.

\*Janeba: University of Mannheim (email: eckhard.janeba@uni-mannheim.de); Köhler: University of Mannheim (email: felix.koehler@uni-mannheim.de); Rostam-Afschar: University of Mannheim (email: rostam-afschar@uni-mannheim.de); Steger: University of Mannheim and ZEW Mannheim (email: paul.steger@zew.de).

# 1 Introduction

Municipal governments provide important public services ranging from childcare, energy and water supply to housing. In addition, municipalities are responsible for a large share of public investment. As emphasized by Agrawal et al. (2022), understanding how localities determine policies is important. The empirical challenge is that revenue changes in local budgets are often endogenous to economic and fiscal conditions (Knight (2002), Dahlberg et al. (2008)). Although the literature has made some progress in this regard, which is discussed in more detail below, causal evidence on the dynamic spending response is still scarce. We contribute to the literature by studying a very large, and arguably, truly exogenous shock to local public revenues that allows us to analyze at a disaggregated level the tax, net asset position and expenditure response of treated municipalities in Germany. Moreover, we evaluate the shock’s spillover effects by analyzing neighboring municipalities’ tax rate responses and the real response via firm entries and exits in treated cities.

In late 2020, the biotech company Biontech, headquartered in Mainz, Germany, successfully developed one of the first effective vaccines against the novel coronavirus and subsequently enjoyed dramatic increases in corporate profits. As profits are also taxed through the local business tax, the city of Mainz and two other cities (Idar-Oberstein and Marburg) that host Biontech production units experienced unexpected windfall tax gains of more than 100% of annual business tax revenues before the shock (increasing in Mainz from €0.15 billion in 2020 to €0.65 billion in 2021 and to €1.25 billion in 2022). In a first step, we ask the question how local public finances respond to windfall tax gains by estimating the Biontech-induced tax gain and the dynamic budgetary response. We compare treated municipalities’ responses to a control group consisting of other cities in the same state of Rhineland Palatinate using a synthetic difference-in-differences approach. Our results are confirmed by standard difference-in-differences methods and comparisons to Tübingen, which headquarters the biotech firm Curevac, which was a promising, but ultimately commercially unsuccessful candidate for producing a coronavirus vaccine at the time. Compared to the existing literature, we also expand the scope of the budgetary response by including municipal balance sheets, with a focus on public debt and capital reserves. As it turns out, observing municipalities’ net asset position is essential in understanding such a large shock.

We document large cumulative revenue increases of the order of €3,440 per capita, solely driven by changes in local business tax revenue. This happens despite treated municipalities sharply cutting their local property as well as business tax rates one year into the shock in 2022 relative to the control units. We find that around half of the windfall revenue gain was used to repay public debt and to build up capital reserves. Effects on discretionary spending, such as public investment or the local public workforce, cannot be detected. Mechanically higher contributions to the fiscal equalization system make up for the remainder of the use of the tax revenue gain. Hence, we document a rather fiscally cautious response to the Biontech shock.

This is somewhat surprising, since even if policymakers believed the shock to be only temporary, the size of the positive shock would have allowed higher discretionary spending for

several years. This suggests that higher tax revenues do not necessarily lead quickly to higher public investment. However, lower levels of debt and higher equity provide fiscal space for increased spending in the future. We document that fiscal oversight may limit the degree to which municipalities can use capital reserves. Fiscal oversight is focused strictly on budget deficits irrespective of the net asset position, complicating the process of distributing the funds over several years.

In a second step, we study the windfall gains' spillover effects. Mainz substantially reduced its local business tax rate by 4.55 percentage points in 2022 (a decrease by around 30%). Compared to the control group, treated municipalities reduced the local business tax by 4.38 percentage points and somewhat less its property tax by 0.7 percentage points. This may trigger tax rate responses in neighboring municipalities which often are in direct competition for firms and business activity.

Using data on local tax rates until 2023, we document that in close geographical proximity to Mainz, municipalities reduced their (effective) local business tax rate on average by 0.26 percentage points (or roughly 2%) relative to more distant municipalities, indicating that local business tax rates are strategic complements. However, the size of the response is very small. We find no or delayed tax rate responses in the neighborhood of the two other, smaller treated cities of Idar-Oberstein and Marburg, perhaps because those municipalities only passed their tax rate changes later in 2022, leaving neighbors less time to respond in the same year. Our analysis contributes to the literature on the spatial reach of fiscal competition (Janeba and Osterloh (2013), Eugster and Parchet (2019), Parchet (2019)) and the nature of strategic tax interaction (Allers and Elhorst (2005), Devereux et al. (2008), Parchet (2019)).

The tax cut, but also Biontech's success itself, may attract new firms, especially in the biotech sector. We do not find an increase in the share of firm entries in Biontech's sector in Mainz, however. In response to the Biontech-induced shock on Mainz' economy, we find no statistically significant increase in overall firm entries, neither in the domain of new firms nor in the relocation of firms from elsewhere. However, relative to other similarly sized cities, we find on average 9% fewer firm exits after the tax cut. Moreover, using firm-level data on Mainz, we find no significant increase of firms in the biotech industry, which was a declared goal of Mainz' tax policy.

The size of the Biontech shock raises the question how such breakthrough shocks are linked with smaller, more common revenue shocks. Local governments can use additional revenue to increase expenditure, change their net asset position or decrease taxes. One empirical question is whether a tendency to spend the full amount of additional revenue found for smaller shocks in the literature also exists for larger revenue shocks. To answer the question whether this so-called flypaper effect disappears with shock size, we analyze more systematically the relationship between budget shock size and the spending response by comparing our estimate to those of 45 estimates from 22 studies in the literature. We find that for small shocks, the budgetary response seems to be going in any possible direction while larger shocks, though fewer in number, concentrate closer to 1. That is, an additional unit revenue results in an additional

unit of spending. Our results are consistent with a negative relationship between the spending response and size of the shock as a large part of additional revenue in our case is used for tax decreases and an improvement in the net asset position.

This paper is structured as follows. Section 2 briefly discusses the business breakthroughs and their relevance for municipal budgets, background of COVID-19 vaccine development, and the fiscal institutional framework in Germany. In Section 3, we present the data sources. Section 4 discusses our empirical strategy, Section 5 reports results on the budgetary response in the treated municipalities and Section 5.5 and section 5.7 discuss the economic and competition effects of the Biontech shock. Sections 6 and 7 discuss the results and conclude.

## 2 Businesses, Breakthroughs, and Municipal Budgets

Municipal tax revenues in Germany are tied to local business profits and very sensitive to business cycles, bankruptcies, and breakthroughs. There exist several cases of single firms experiencing large and unexpected profit gains, for example, as the result of a global health crisis or a geopolitical confrontation. In the former, breakthrough innovations such as an effective vaccine might originate from a single firm leading to geographically concentrated, large profits, or regional windfall tax gains. In the latter case, national governments might for instance supply foreign nations with military equipment which suddenly scales up the production of such firms. Table A7 illustrates this point by pointing to a few recent prominent cases. Very large profits might benefit the fiscal situation of municipalities directly through the means of local corporate taxation as in Germany or indirectly through fiscal equalization payments. Plausible channels are more income and sales tax revenues through increased employment or rising property tax revenues as a consequence of increased house values. The Biontech shock is a case in point for an unexpected breakthrough that affects municipal budgets directly and indirectly via spillover effects.

### 2.1 The Biontech Shock

As the global pandemic unfolded, research into the development of an effective vaccine against the Sars-Cov-2 virus kick-started around the world. One of the ultimately successful vaccine developers was the biotechnology company Biontech headquartered in Mainz, Germany. Prior to the pandemic, the company was engaged in cancer research based on the fairly novel mRNA-method. On the eve of the pandemic, the company largely switched to develop an mRNA-based COVID-19 vaccine by collaborating for production with the US pharmaceutical company Pfizer to scale production and distribution.

First clinical trials started in April 2020 and by November, phase III clinical trials were concluded. In the latter trials, the vaccine showed high efficacy rates and was approved for clinical use by the US, UK and European health authorities by the end of 2020. Biontech's vaccine production initially took place in three locations across Germany: The headquarters in Mainz (state of Rhineland-Palatinate), and two additional production sites in the city of

Idar-Oberstein (Rhineland-Palatinate) and the Hessian city of Marburg. Figure 3 shows a map of the three cities and their surrounding municipalities.

With 665 million administered doses in the European Union and 402 million in the United States by 2023 (Our World in Data (Oxford University) (2024)), the vaccine quickly became one of the most widely used around the globe. As depicted in Figure 1, this translated into a strong increase in Biontech’s revenues and profits. Net income rose dramatically from €15.2mn in 2020 to €10.3bn and €9.4bn in 2021 and 2022, respectively. This translated into a strong increase of local economic activity as measured by gross domestic product per capita in Mainz. It increased by around 70% in 2021, while the average county-level GDP per capita in Germany stayed roughly flat.

A tale of what could have happened instead is provided by Tübingen, a university town in the south of Germany. It hosts biotech company Curevac, which, at the time, seemed equally well positioned to launch a viable vaccine against COVID-19. Figure 1 plots its share price, normalized to its price at its initial public offering in August 2020, along with that of Biontech. It suggests that market valuations started diverging only in April 2021, implying that markets (correctly) anticipated increasing profits at Biontech compared to Curevac only in 2021, the year when Mainz’ budget was already impacted by increased business tax revenues.

## 2.2 Municipal Public Finances in Germany

In Germany, there are two taxes levied on firm profits. Companies pay the national corporate income tax (“*Körperschaftsteuer*”), currently set at 15% of taxable profits. Half of those tax revenues flow to the federal budget, while the remainder is apportioned across the 16 states based on a specific formula. The second relevant profit tax is the local business tax (“*Gewerbesteuer*”) whose tax rate varies locally, but is typically another 15% of taxable firm profits. While the tax base and deductions are set at the federal level, municipalities autonomously decide on a tax multiplier that determines the ultimate tax burden.<sup>1</sup> The apportionment of local business taxes paid by a firm operating in several municipalities within Germany is roughly proportional to the firm’s local economic activity (Federal Ministry of Finance (2023)).<sup>2</sup>

While the federal and state governments have seen tax revenue increases as a consequence of Biontech’s increased corporate income tax payments of €4.8bn and €3.5bn in 2021 and 2022, respectively, the local business tax channels around half of these tax revenues to a firm’s site cities. As a result, all three of Biontech’s firm sites have benefited from strong increases in tax revenues, while other municipalities benefited only indirectly at best. In terms of municipalities’ revenue, the local business tax typically constitutes the most important tax source. In aggregate, it generated approximately €70bn in Germany in 2022 (around 50% of overall municipal tax revenue).

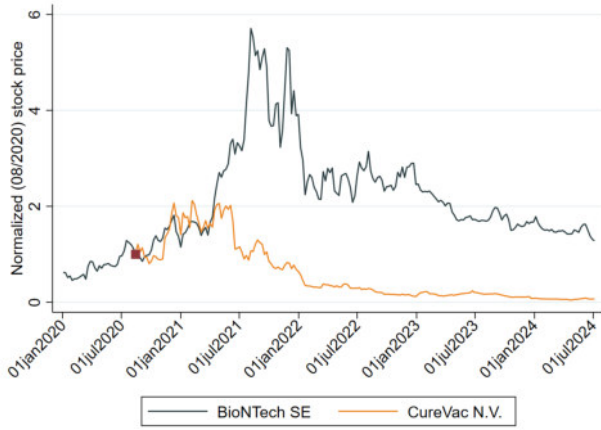
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<sup>1</sup>The ultimate local business tax rate is calculated by multiplying the nationally set base rate of 3.5% times the local multiplier, e.g.  $3.5\% \times 440\% = 15.4\%$ . The local property tax rate is calculated by multiplying the nationally set base rate of 0.35% times the local multiplier.

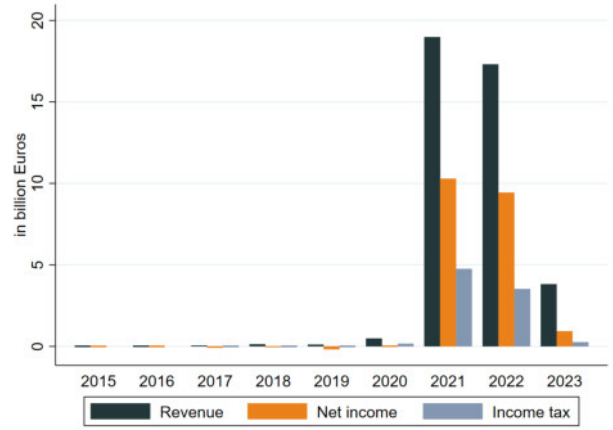
<sup>2</sup>In short, if a firm has multiple production sites in Germany, the tax bill from the local business follows the share of the wage bill.

Figure 1: The Biontech Shock and Distribution of Tax Revenue Growth

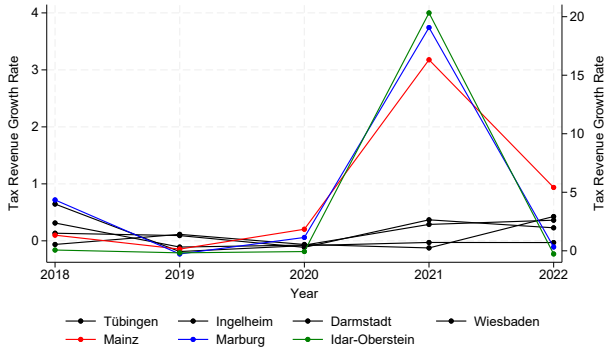
(a) Weekly Normalized Closing Stock Prices



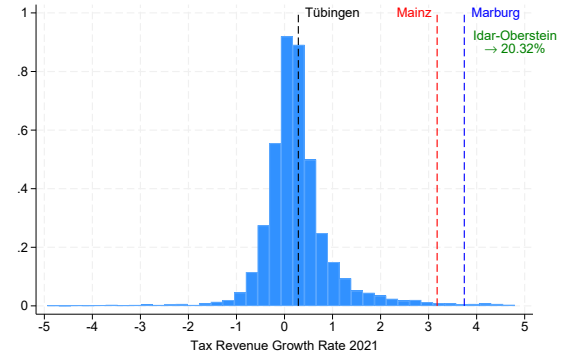
(b) Biontech Key Financial Figures



(c) Tax Revenue Growth Rates 2018-2022



(d) Tax Revenue Growth Rates in 2021



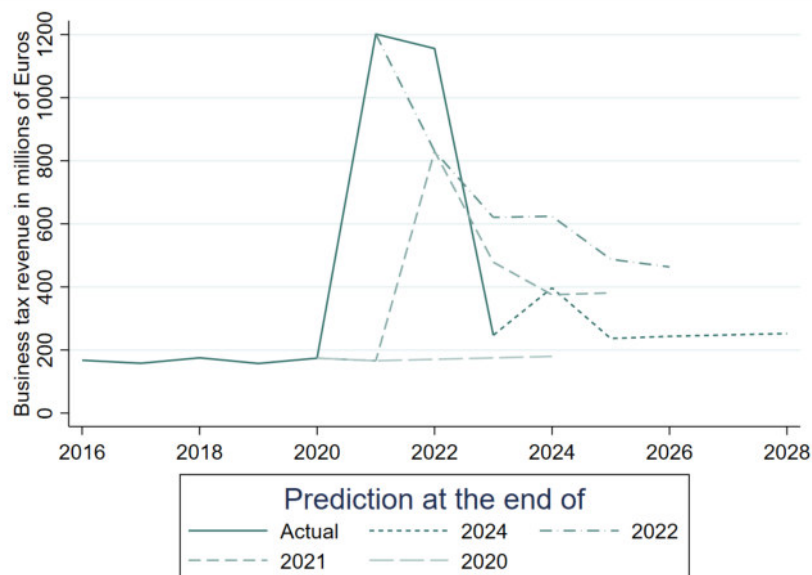
**Notes:** Figure (a) shows the weekly normalized closing stock prices of Biontech (since Jan 2, 2020) headquartered in Mainz with establishments in Idar-Oberstein and Marburg and Curevac (since Aug 14, 2020) headquartered in Tübingen. The stock prices start diverging on April 1, 2021, when Biontech released results on the efficacy of its vaccine of 91.3% and had delivered more than 450 million vaccine by 6 May 2021. On June 16, 2021 Curevac results showed an efficacy of its vaccine of 47%. Figure (b) shows the increase in Biontech's net income growth from €15.2 million in 2020 to €10.3 billion in 2021 and €9.4 billion in 2022. Figure (c) shows increases in tax revenues in selected municipalities with biotechnology firms. Figure (d) shows how the Biontech tax revenue shock compares to the growth rates in tax revenues among approx. 11,000 municipalities in Germany in 2021 in the range of -500% and 500%.

## 2.3 Theoretical Considerations

In order to hypothesize how the Biontech shock impacts municipalities' budgets, it matters how temporary it is perceived to be. According to the tax-smoothing theory, fluctuations in tax rates can amplify distortions from taxation and should be avoided. Instead, governments should keep tax rates constant over time by running temporary budget deficits or surpluses to smooth over temporary shocks (Barro; 1979). However, this is not the case for permanent shocks as governments incur perpetually more debt or, in the event of positive shocks, capital reserves. In the latter case, it can be beneficial to reduce taxes since resources could be used more productively in the economy as opposed to government savings. It is thus paramount to elicit decision makers' expectations about the nature of the shock.

Figure 2 sheds light on Mainz' expectations of future business tax revenues at different points in time based on its budget plans. When its town council voted to decrease the local business tax rate for 2022 at the end of 2021, budget plans predicted a revenue spike to around €800 million in 2022 before settling in the following years at annual revenues of around €400 million, which is approximately two times as much as in the years before 2021. An updated forecast in 2022 already incorporated the revenue increase to €1,200 million in 2021 as well as the diminishing effect of the business tax rate reduction in 2022. At that time, Mainz predicted that revenues would converge back to even more than €400 million in the next couple of years. Instead, business tax revenues were already in 2023 close do €200 million again. It turned out that the shock was larger than expected initially, but at the same time it was also more temporary in nature than Mainz predicted.

Figure 2: Business Tax Revenue and Predictions in Mainz



**Notes:** This Figure depicts Mainz' yearly tax revenue from the local business tax in millions of Euros over time as well as the city's prediction of future revenue development at different points in time. Source: Mainz' budget plans.

Nevertheless, given these expectations, a modest tax rate increase can be justified as revenues are predicted to double at least in the medium term. This should, however, be reconsidered at the end of 2024 when tax revenues were expected to return to former levels. The theoretical effect on debt is less clear. As pointed out, the shock was larger than predicted initially. For a highly indebted municipality such as Mainz at the time, it might be sensible use an unexpected positive shock to repay debt. This would decrease subsequent interest payments and increase the capacity to smooth tax policy in the future. If at all, capital reserves should be built up only if outstanding debt is fully paid off. In terms of expenditure, permanently higher revenues open the door to more public expenditure, especially if there exist (investment) projects which previously could not be implemented due to budget constraints. We thus hypothesize that the shock led to a decrease in tax rates and debt as well as an increase in expenditure, with the exact extent of each an empirical question.



## 3 Data Sources

### 3.1 Municipal Balance Sheet and Tax Data

To study the budgetary response of the Biontech shock, we rely on comparable data across municipalities. As municipal accounting rules' details are a state matter, data of municipal budgets are not fully comparable across states. A comparison is further complicated by the switch from traditional cash-based to accrual accounting (Christofzik; 2019), which was mandated in 2009, but implemented at different points in time between states.

To make use of fully comparable data across budget items and time, we restrict our baseline sample to the state of Rhineland-Palatinate and exclude Marburg. We chose Rhineland-Palatinate because two out of the three treated municipalities (Idar-Oberstein and Mainz) are located in this state, including the Biontech headquarter in Mainz. The control group is made up of the largest 33 municipalities in the same state. Although the small sample poses problems in terms of inference, it is beneficial in other aspects. Given the relatively small sample size, we digitized municipal budgets by hand, including municipal balance sheets. This is an improvement over official, ready-to-use municipal finance datasets, which typically do not contain information on assets, liabilities, and equity (i.e., capital reserves) or budget forecasts. For our context, balance sheet data are particularly important because under accrual accounting rules any budget surplus which is not spent currently enters the balance sheet as a capital reserve. Given the size of the fiscal shock in question, large parts of the tax revenues would be not accounted for without balance sheet data.

Another advantage of our data is its range from 2016 to 2024. Data for 2023 and 2024 stem from budgetary planning and are preliminary, but are indicative of likely values and allow us to study the aftermath of the Biontech shock as perceived by municipalities in real time. Our data contains detailed budget items and municipal balance sheet data, which are described in detail in the Appendix A.

### 3.2 Firm Entry and Exit Data

Data on firm exits and entries at the level of district-free cities ("Kreisfreie Städte") between 2016 and 2023, disaggregated by firm relocations and new firms, are provided by the Federal Statistical Office .

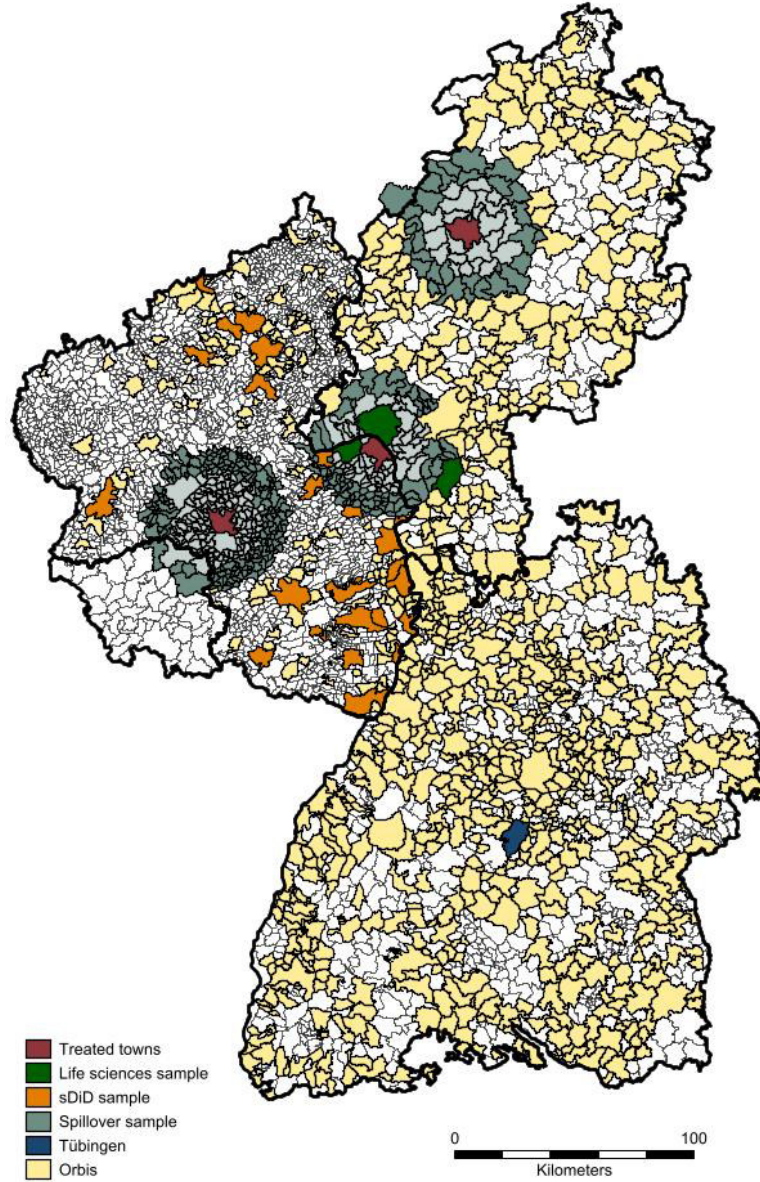
To empirically test whether tax policy achieved its goal of fostering a biotechnology sector in Mainz, we use Orbis data on newly established firms and compare the development in Mainz to other municipalities in the states of Rhineland-Palatinate, Hesse, and Baden-Württemberg (conditional on having at least one new firm per year between 2017 and 2024).<sup>3</sup>

If more biotech firms are drawn to Mainz, its share of biotechnology firms among new firms should increase following the Biontech shock. During this entire time period, a total of 2,900 new firms across all industries were established in Mainz and 190,997 in the entire

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<sup>3</sup>A sample of arguably more comparable municipalities, which also host a significant share of life sciences firms, i.e. Ingelheim, Tübingen, Wiesbaden and Darmstadt yields similar results.

Figure 3: Map of Samples



**Notes:** The Figure depicts municipalities used in the respective estimation samples. Going from north to south, treated municipalities are Marburg, Mainz and Idar-Oberstein. Orange municipalities are the donor pool for the baseline synthetic control group. Neighboring municipalities within 20 kilometers and between 20 and 30 kilometers are shaded in light and dark teal. Thick black lines indicate state borders. Going from north to south, the states are Hesse, Rhineland-Palatinate, Saarland and Baden-Württemberg. Tübingen is indicated in blue. Yellow municipalities are part of the Orbis sample that had at least one new firm each year between 2017 and 2024.

sample, but these numbers contain only 14 and 853 firms in the field of “Scientific research and development” (NACE industry code 72), respectively. Biontech spin-offs are excluded by dropping all observations that have Biontech in the company name.

### 3.3 Spillover Municipalities

To analyze tax competition effects, we focus on municipalities neighboring those affected by the Biontech shock within 20 and 30 kilometers. In the case of Mainz, these include Ingelheim, Wiesbaden, and Darmstadt, municipalities that actively compete in the life science sector. Data on tax multipliers are provided jointly by the Federal Statistical Office and the State Statistical Offices until 2023.

## 4 Empirical Strategy

### 4.1 Synthetic Difference-in-Differences

Identifying an effect relies on a credible counterfactual of what would have happened to public finances in treated municipalities after 2020 absent the shock. A necessary condition for establishing causality is the parallel trends assumption, i.e. the parallel development of key public finance outcomes prior to the shock. To establish a suitable control group and establish parallel trends, we turn to the method of synthetic difference-in-differences (Arkhangelsky et al.; 2021). While we run a canonical difference-in-difference regression on all budget items based on Equation (2), the fairly small sample size makes synthetic difference-in-differences more appealing as a baseline specification in our setting. The average treatment effect on the treated (ATT) is computed as follows:

$$(\hat{\beta}^{sdid}, \hat{\mu}, \hat{\alpha}, \hat{\xi}) = \arg \min_{(\beta, \mu, \alpha, \xi)} \sum_{i=1}^N \sum_{t=1}^T (Y_{it} - \mu - \alpha_i - \xi_t - D_{it}\beta)^2 \hat{\omega}_i \hat{\lambda}_t \quad (1)$$

We run Equation (1) on all expenditure and balance sheet categories described in Table A1 separately. Letter  $\mu$  refers to the intercept, while  $\alpha_i$  and  $\xi_t$  denote municipality and time fixed effects, respectively. The binary treatment indicator  $D_{it}$  takes on the value of one for the treatment municipalities as of 2021 and zero otherwise.

Synthetic difference-in-differences combines the standard canonical difference-in-differences approach with a single treatment period (non-staggered implementation) and the synthetic control period developed by Abadie et al. (2010) using a synthetic control group for the standard difference-in-differences approach. The synthetic control group is assembled by assigning strictly positive weights  $\hat{\omega}_i$  to observations such that pre-treatment evolution of the dependent variable is parallel in the treatment and the (synthetic) control group. Moreover, time weights  $\hat{\lambda}_t$  are used to assign more weight to time periods pre-treatment that are similar to post-treatment periods. The intuition is that this represents a more valid counterfactual since the post-treatment evolution of the synthetic control method is likely how the treatment group

would have evolved had it not been treated. Synthetic difference-in-differences yields an average treatment effect on the treated (ATT) that is simply the average of  $\hat{\beta}^{sdi}$  in the post-treatment period.

Conventional standard errors in this setting are likely incorrect due to finite sample bias in this small estimation sample. Synthetic difference-in-difference provides a work around by using bootstrapped standard errors. We provide standard error estimates by using 5,000 bootstrap replications and cluster on the municipality level.<sup>4</sup>

## 4.2 Difference-in-Differences

As an alternative method, we estimate treatment effects using a simple difference-in-differences model with fixed effects according to regression equation

$$y_{it} = \beta \cdot Municipality_i \times Post\ 2020_t + \theta_i + \mu_{st} + \epsilon_{it}, \quad (2)$$

where  $y_{it}$  is an outcome variable measuring business activity, industry composition or tax rates in municipality  $i$  and year  $t$ ,  $Municipality_i$  is the respective municipality under consideration and will in most cases be Mainz,  $Post\ 2020_t$  is an indicator variable equal to one for years between 2021 and 2024, when Mainz was fiscally affected by Biontech’s success. In an alternative specification, we change the indicator to years between 2022 and 2024, since economic effects might not set in at the time of Biontech’s success, but only after Mainz substantially decreased its local business tax rate in 2022. Fixed effects  $\theta_i$  and  $\mu_{st}$  control for municipality and state×year-specific effects and errors  $\epsilon_{it}$  are clustered at the municipality level.

## 5 Results

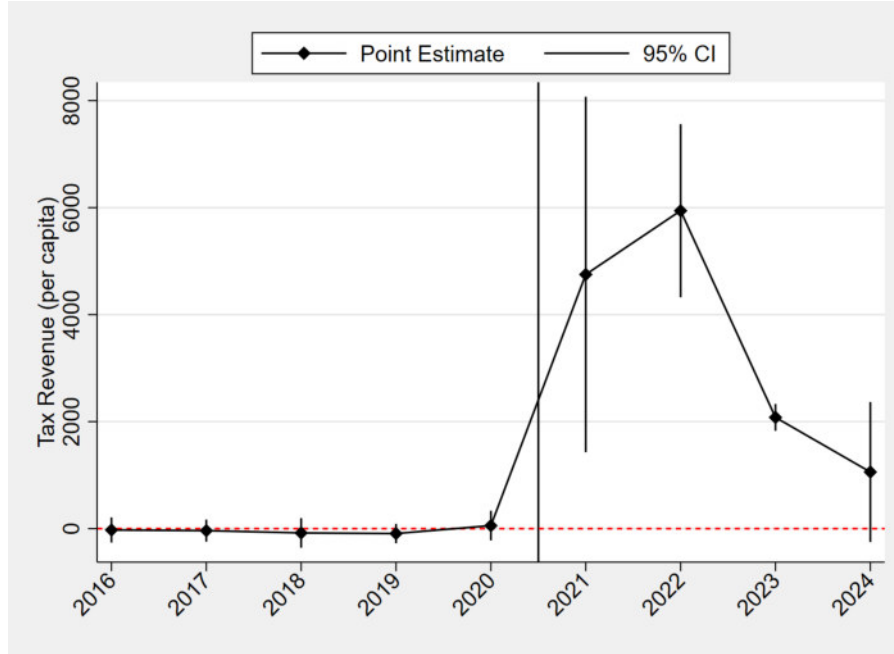
### 5.1 Tax Revenues

We report estimates of the windfall tax gain from hosting Biontech facilities in Figure 4, which depicts an event study plot of tax revenues in Euros per capita based on Equation (1). The dynamic treatment effect estimate shows that tax revenues increased dramatically in the post-treatment years, peaking at around €6,000 per capita in 2022 before quickly converging back to the synthetic control group after that, underlining that the boost was short-lived. To provide some context, Mainz and Idar-Oberstein had total revenues per capita of around €3,400 and €2,500 in 2020, respectively. The average treatment effect on the treated (ATT) among all post-treatment years is €3,440 per capita, which is statistically different from zero for every conventional significance level (p-value: 0.000).

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<sup>4</sup>When we run the regression for the treated units separately, bootstrap estimation does not work and we rely on placebo estimation (Arkhangelsky et al. (2021))

Figure 4: Tax Revenues in Euros per capita



**Notes:** The Figure compares treated municipalities (Mainz and Idar-Oberstein) to a weighted synthetic control group with similar pre-treatment trends. The results show a sharp increase in tax revenues starting in 2021, peaking at around €6,000 per capita in 2022, before returning toward control group levels in 2023. The average treatment effect on the treated (ATT) is €3,440 per capita.

Before moving on to studying the detailed spending response, we perform a simple exogeneity check in Figure 5. We regress the pre-treatment changes (2016 to 2020) of various economic covariates, budget items and local tax multipliers on the treatment variable for the sDiD sample. We can detect no statistically divergent trends in the Biontech municipalities compared to the control sample. This is yet another piece of evidence that the Biontech shock was exogenous from the viewpoint of local policymakers and not the result of fiscal policy decisions at the local level.

Figure 5: Biontech Shock and pre-treatment trends



**Notes:** The figure represents bivariate regression estimates: we regress the pre-treatment change (2020-2016) in a wide range of economic, budgetary and fiscal variables on the treatment variable. Standard errors are computed by 5,000 bootstrap replications

## Comparison to Biontech's Pre-Tax Profit

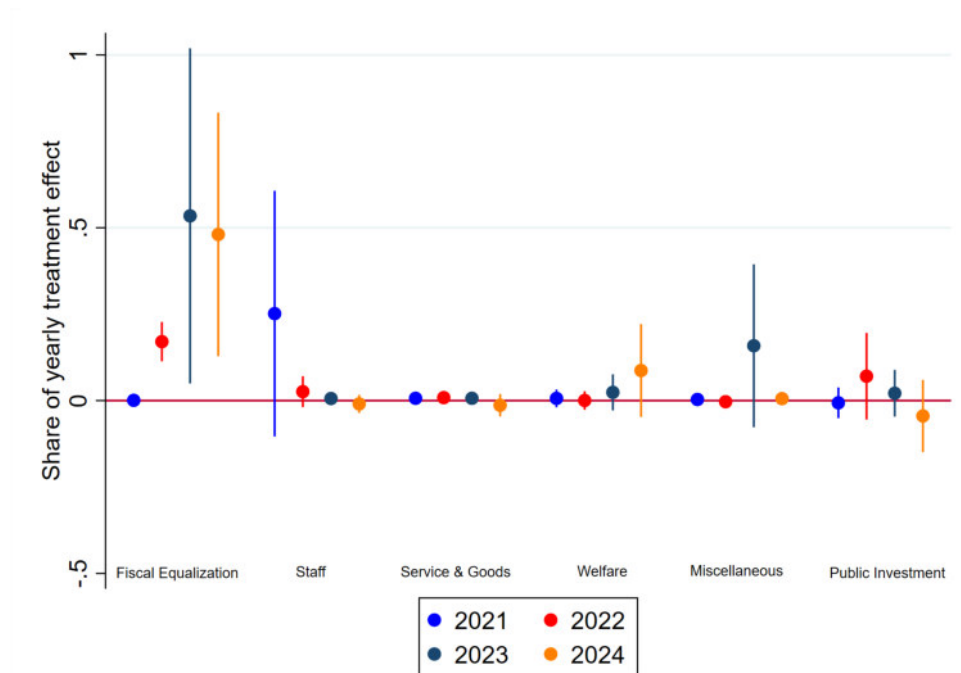
A simple back-of-the-envelope calculation linking the treatment effect size here with Biontech's financial statements can serve as a plausibility check. By assuming that Biontech's income tax payments depicted in Figure 1 (b) only accrued in Germany and local business tax revenue is distributed only among the three municipalities in proportion to their inhabitants and statutory tax rate, hypothetical average per capita business tax revenue for the years from 2021 until 2023 sum to around €12,200 per capita. This compares well to the cumulative estimates of excess tax revenue per capita of around €12,700 reported in Figure 4. Thus, there is a good match between the average estimated revenue response and the hypothetical distribution of taxes paid by Biontech according to its financial statements, corroborating this main result.

## 5.2 Expenditure Response

Having collected detailed data on budget items, we can not only estimate the revenue but also the expenditure responses. We estimate the latter from running Equation (1) on all budget items. We present estimates on all budget items in absolute terms in Figure 6 and 7 as the fraction of each budget items of the annual ATT. Investment, cash loans and capital reserves are stock variables and for this reason, we estimate the year-on-year changes. To maintain readability, we split the spending response by current spending (6) and the spending on debt repayment and inflow into capital reserves (7). To understand how strongly the spending response deviates from regular local fiscal policy, we plot the share of the same budget items

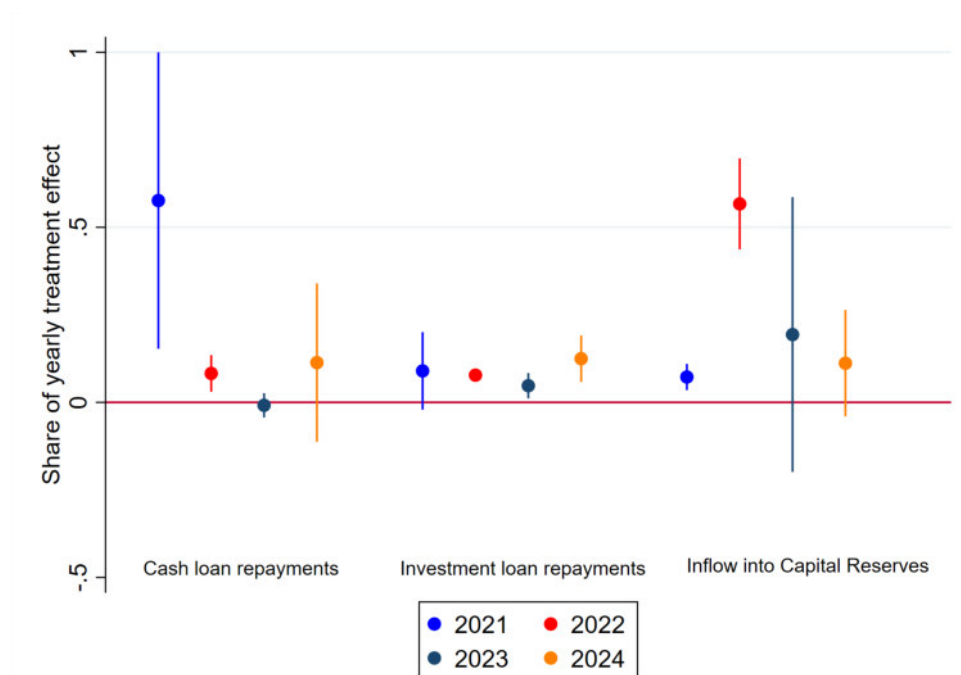
among the entire budget in pre-treatment year 2020 below in Figure 8.

Figure 6: Budgetary Response: Annual treatment effect shares (current spending)



**Notes:** The estimates represent the spending response of major budget categories in every post-treatment year as a share of the respective annual treatment effect.

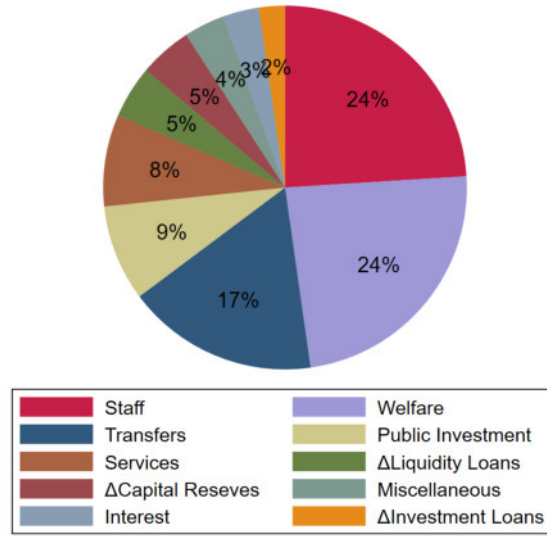
Figure 7: Budgetary Response: Treatment Effects Shares Debt & Reserves



**Notes:** The estimates represent the spending response of major budget categories in every post-treatment year as a share of the respective annual treatment effect.



Figure 8: Budget Shares 2020



**Notes:** This Figure shows 2020 budget shares among the entire budget in treated municipalities. In the absence of the Biontech shock, the treated municipalities spend almost half of their budget on staff and welfare whereas debt repayments or inflows into capital reserves only make up for small shares of overall spending. This is in stark contrast to the fiscal response to the Biontech shock shown in Figure 6 and Figure 7.

It becomes clear that the payments into the statewide fiscal equalization scheme, debt repayment and filling up capital reserves dominate the budgetary response in the treated municipalities. While the first is mechanical due to the workings of fiscal equalization systems, the latter two indicate that local policy makers pursue a fiscally cautious strategy. In the area of current spending, we see statistically insignificant responses on discretionary spending such as staff or public investment, which represent the largest and fourth largest share, respectively, in the 2020 budget, as shown on the right-hand side. However, even though the discretionary spending responses are imprecisely estimated the estimates might still be economically fairly significant. For instance, we estimate the spending response on personnel to be around €263 per capita. Interestingly, this is mainly driven by the city of Mainz paying into the staff pension fund upfront which again resembles a precautionary spending response. We note that the public investment response is heterogeneous in Mainz and Idar-Oberstein. When running Equation (1) on both cities separately, we see that public investment increases significantly in Mainz in 2022 and 2023, but converges to the synthetic control group mean in 2024 (see Figure A14).

There is a strong reduction in public debt, particularly for short-term liquidity loans, while in the 2020 budget both kinds of debt were increased. Moreover, we estimate a large inflow into capital reserves. Hence, approximately 50% of the windfall tax gains are used to improve the fiscal position of the municipality in the long run. This compares to a 2020 budget share of approximately 5%. The single biggest share, however, flows into the fiscal equalization system. Municipalities hand over a portion of local business tax revenues to the state and federal level via the business tax levy (“*Gewerbesteuerumlage*”). Municipalities belonging to a county like Idar-Oberstein additionally cede some of their revenue to the county level via the county levy



(“*Kreisumlage*”). But more importantly, municipalities with large own tax revenues are likely to no longer qualify to receive intergovernmental transfers from the municipal fiscal equalization system and hence become net contributors. As discussed above, payments from or contributions to the fiscal equalization system in year  $t$  are usually determined by a municipality’s fiscal position in year  $t - 2$ . This explains the fiscal response materializing only in 2023 (see A6 in the Appendix). This could also be one reason for building up capital reserves in the first place. As municipalities anticipate large mandated intergovernmental transfers to the equalization system, they need to bridge the time until payment occurs.

## Comparison to Tübingen

The fact that another German city hosted an equally promising company at the time can be exploited to confirm results produced by the synthetic control group. As mentioned above, Curevac of Tübingen was also heavily invested in COVID-19 vaccine research, but ultimately failed commercially. In this sense, Tübingen might be viewed as a good example of what might have happened to Mainz absent Biontech’s success. Since Tübingen is located in the state Baden-Württemberg, budget reporting requirements differ from those in Rhineland-Palatinate and not all variables studied above are observable. Despite these difficulties, the case of Tübingen confirms our results based on four public finance variables.<sup>5</sup>

## 5.3 Tax Response

We estimate the response on the local business tax and the property tax multiplier, which are set by the municipalities themselves. Local tax multipliers are measured in percentage terms such that any change needs to be interpreted as percentage point changes. Note that the final tax rate is determined by multiplying by the baseline rate of 3.5% for the local business tax and by 0.35% for the property tax.

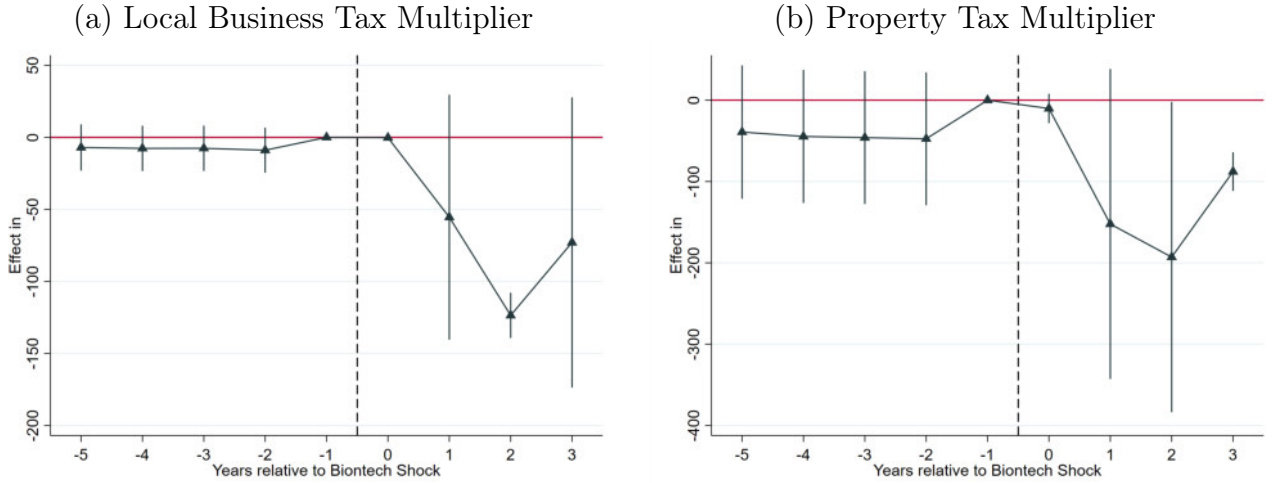
Treated municipalities reduced their tax rates relative to the control units, as depicted in Figure 9 (a) and 9 (b). Two years into the shock, the treatment group reduced their local business tax multiplier by about 125 percentage points whereas the property tax multiplier declined by almost 200 percentage points relative to the control group. This corresponds to a tax rate decrease of 4.38 percentage points and 0.7 percentage points, respectively.

On average, the tax cuts are temporary, because as of 2024 tax rates start converging to the control group. This effect is driven by the response of Idar-Oberstein, which reverted its local business tax multiplier back to 420% after two years. Mainz and Marburg only reverted their local business tax multiplier back to 440% and 380%, respectively, in 2025 after three years. The reason why the cities of Mainz, Marburg, and Idar-Oberstein swiftly took back tax cuts is

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<sup>5</sup>In Figure A32 in the Appendix, we plot the difference between selected budget items in Mainz and Tübingen, normalized to zero in 2020. Although there are some differences compared to the synthetic difference-in-differences estimates studying for Mainz alone, for example in Figure A12, differences in terms of timing can be attributed to different accounting standards in the data used here (i.e. “*Ergebnishaushalt*”), since Tübingen only provides this. Although pre-trends before 2021 are not perfect, this can hardly be expected when comparing just two units. Overall, these simple differences seem to be in line with our main results.

Figure 9: Tax Policy



**Notes:** Figure shows the changes in (a) local business tax multiplier, and (b) the property tax multiplier. Both estimates compare treated municipalities to a synthetic control group, estimated using a synthetic difference-in-differences (SDID) approach. Both types of taxes have been reduced in response to the Biontech shock but revert after three years.

mostly due to the fact that in 2024, it failed to balance its budget. This was not least due to Biontech’s deteriorating net income after vaccine demand collapsed.

Why did municipalities undo tax rate decreases so quickly even though they built up substantial capital reserves that could have financed a budget shortfall? One reason is that some of the reserves were already allocated to specific purposes like debt repayment of loans with longer maturity. Another reason is that the responsible fiscal oversight authority in Rhineland-Palatinate insisted on balancing the budget irrespective of the favorable net asset position. For example, the sheer size of Mainz’ growing deficit of €103 million in 2023 and around €200 million in 2024 led the fiscal authority to refuse budget approval, especially as it could not see any measures being taken to contain the deficit. Thus, tax smoothing in this case is constrained by institutional frictions.

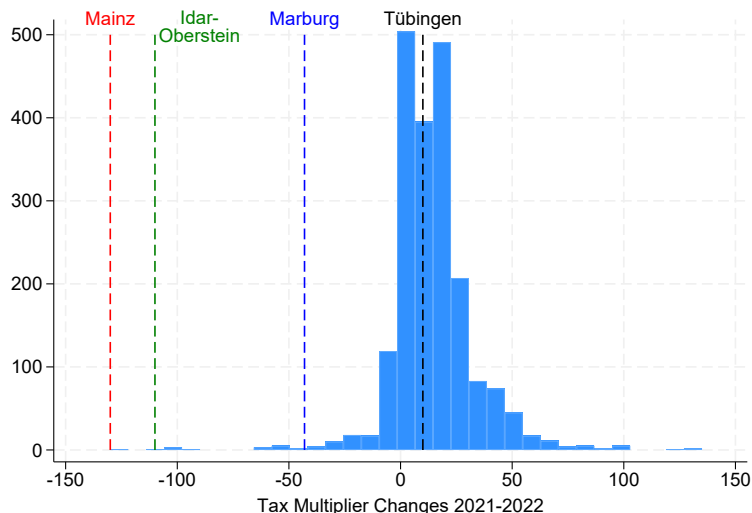
Political factors might have played a role as well. While the mayor can put forward changes to local tax multipliers, the power to change them sits with the local council. Idar-Oberstein held mayoral elections in 2022 and Mainz in 2023. Statewide council elections were held in 2024. However, the mayoral election in Idar-Oberstein only saw one candidate and in both cities the reductions in local tax multipliers were passed unanimously by the local council. Also, the mayoral election in Mainz was the result of the incumbent mayor moving into state politics in 2022 which does not suggest a politically motivated tax cut in 2022.

## 5.4 Robustness

To put the business tax multiplier response’s magnitude into perspective, we plot the empirical distribution of non-zero year-on-year business multiplier changes for all of the approximately 11,000 German municipalities between 2021 and 2022 in Figure 10. Mainz’ and Idar-Oberstein’s

tax multiplier cuts of 130 and 110 points in 2022, respectively, were the largest tax cuts in this time period. Marburg’s cut of 43 points still put it in the 99th percentile of negative tax changes. Also, tax decreases play a minor role in this time period, emphasizing the large response in treated municipalities.

Figure 10: Local Business Tax Multiplier Changes (2021-2022)



**Notes:** This graph depicts the distribution of non-zero year-on-year local business tax multiplier changes in 2021 and 2022 among all of the approximately 11,000 German municipalities. 2022 tax cuts in Mainz, Idar-Oberstein and Marburg are marked in dashed lines. Tübingen increased its tax multiplier in 2021 from 380% to 390%.

## 5.5 Firm Responses

Table 1: Business Entries and Exits

	Entries			Exits			Net
	(1) Total	(2) New	(3) Relocations	(4) Total	(5) Closures	(6) Relocations	(7) per capita
Mainz×Post 2020	-0.008 (0.034)	0.031 (0.036)	-0.099 (0.131)	-0.106** (0.038)	-0.045 (0.049)	-0.054 (0.047)	0.728*** (0.161)
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State×Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	808	808	808	808	808	808	808

This table examines the business activity response in Mainz to the Biontech shock, estimated using a difference-in-differences (DiD) approach with municipality and state-year fixed effects. Standard errors are clustered at the municipality level. Regressions estimated according to Equation 2. Outcomes are the logarithms of the variables indicated in (1)-(6). Standard errors in parentheses.

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 1 presents regressions of the logarithm of business entries in Columns 1-3 and exits in Columns 4-6 based on the difference-in-differences estimator according to Equation (2). Since

the sample provided by the Federal Statistical Office between 2016 and 2023 is on the county level, only the approximately 100 district-free cities, which exhibit a dual role as counties and municipalities are used.

Compared to other large municipalities and the time period before 2021, Mainz experienced no statistically significant change in firm entries in Column 1. Two subcategories, new firms and relocations to Mainz, also do not change significantly. Exits, on the other hand, decrease by approximately 10% in Column 4. Disentangling the exit effect in less closures of established firms and fewer relocations from Mainz exhibit a negative point estimate, but are not significantly different from zero. The regression of net entries per capita in Column 7 suggests that the overall absolute effect is positive, i.e. less exits more than make up for flat entries. These results suggests that compared to other large municipalities, Mainz did not succeed in attracting more new businesses but a healthier budget and lower taxes might have prevented some firms from closing or relocating elsewhere.

Table 2: Mainz: Industry Share Change among New Firms

	(1)	(2)	(3)	(4)
	NACE 72	NACE 721	NACE 7219	NACE 7211
Mainz $\times$ Post 2020	-0.0008 (0.0010)	0.0001 (0.0008)	0.0004 (0.0008)	-0.0004 (0.0002)
City FE	Yes	Yes	Yes	Yes
State $\times$ Year FE	Yes	Yes	Yes	Yes
Mean(Dep Var)	0.005	0.003	0.003	0.001
N	190,997	190,997	190,997	190,997

Regressions estimated according to Equation 2. Standard errors in parentheses.

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

One stated goal of Mainz' business tax decrease was to build on Biontech's success and create a cluster of biotechnology firms by aligning its local business tax rate with its neighboring municipality of Ingelheim. In addition, the city of Mainz pursued a marketing campaign and formed a strategy of finding designated areas for establishing new firms (Landeshauptstadt Mainz; 2022).

Table 3: Mainz: Industry Share Change among New Firms compared to Tübingen

	(1)	(2)	(3)	(4)
	NACE 72	NACE 721	NACE 7219	NACE 7211
Mainz $\times$ Post 2020	0.0006 (0.0003)	0.005* (0.0001)	0.008* (0.0002)	-0.003* (0.00005)
City FE	Yes	Yes	Yes	Yes
State $\times$ Year FE	Yes	Yes	Yes	Yes
Mean(Dep Var)	0.011	0.009	0.007	0.002
N	3,716	3,716	3,716	3,716

Regressions estimated according to Equation 2. Standard errors in parentheses.

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Results of biotechnology entries as a share of all entries are presented in Table 2. Here,  $y_{it}$  is an indicator variable equal to one if a new firm is part of the respective industry. The outcome variable is defined ever more narrowly from Column 1 to 4, starting with “Scientific research and development” (NACE industry code 72), followed by “Research and experimental development on natural sciences and engineering” in Column 2, “Other research and experimental development on natural sciences and engineering” in Column 3, or, alternatively, “Research and experimental development on biotechnology” in Column 4. All four specifications suggest that Mainz’ share of science-based firms among new firms has not increased.

Table 3 presents results comparing industry shares in Mainz and Tübingen only, since both harbored a promising vaccine manufacturer. Compared to Tübingen, we observe differential effects in the more narrowly defined industries.

Biontech’s success might also have affected other municipalities. This Section explores some potential channels. First, we repeat the exercise shown in Table 2 for the city of Ingelheim in Table 4. The municipality neighbors Mainz and Ingelheim host a number of life sciences firms, most prominently the pharmaceutical giant Boehringer Ingelheim. Agglomeration effects, such as access to the institutions and people that made Biontech successful, are important for firm location decisions and potentially make Mainz a prime location. However, firms value lastingly low tax rates and hence may prefer Ingelheim as a firm location while at the same time benefiting from closeness to Mainz.

Table 4: Ingelheim: Industry Share Change among New Firms

	(1)	(2)	(3)	(4)
	NACE 72	NACE 721	NACE 7219	NACE 7211
Ingelheim $\times$ Post 2020	0.0008 (0.0009)	0.0002 (0.0007)	0.005*** (0.0007)	-0.005*** (0.0002)
City FE	Yes	Yes	Yes	Yes
State $\times$ Year FE	Yes	Yes	Yes	Yes
Mean(Dep Var)	0.005	0.003	0.003	0.001
N	190,997	190,997	190,997	190,997

Regressions estimated according to Equation 2. Standard errors in parentheses.

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Regressions in Table 4 paint a mixed picture. Although the share of life sciences firms among new firms has not changed compared to the control group in aggregated industries in Column 1 and 2, there is a positive change in the share of more disaggregated NACE code 7219 firms and a negative change in the share of NACE code 7211 firms.

## 5.6 Robustness

The results of Table 2 are corroborated by Table 5, which defines the post treatment period starting only in 2022, when Mainz decreased the local business tax rate. While total entries are negative and significantly different from zero in this specification in Column 1, total firm exits in Column 4 are much larger in absolute terms, pointing to a cushioning effect on business

activity through foregone firm exits in Column 7. The envisioned stimulation of business activity materializes in the form of so many fewer exits such that the net effect is positive also in this alternative specification.

Table 5: Business Entries and Exits after 2021

	Entries			Exits			Net
	(1) Total	(2) New	(3) Relocations	(4) Total	(5) Closures	(6) Relocations	(7) per capita
Mainz $\times$ Post 2021	-0.097** (0.035)	-0.063 (0.038)	-0.069 (0.103)	-0.216*** (0.037)	-0.153** (0.045)	-0.162* (0.068)	0.661** (0.217)
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State $\times$ Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	808	808	808	808	808	808	808

This table examines the business activity response in Mainz to the Biontech shock, estimated using a difference-in-differences (DiD) approach with municipality and state-year fixed effects. Standard errors are clustered at the municipality level. Regressions estimated according to Equation 2. Outcomes are the logarithms of the variables indicated in (1)-(6). Standard errors in parentheses.

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 6: Mainz: Industry Share Change among New Firms

	(1) NACE 72	(2) NACE 721	(3) NACE 7219	(4) NACE 7211
Mainz $\times$ Post 2021	-0.004*** (0.0010)	-0.003*** (0.0007)	-0.002** (0.0006)	-0.001*** (0.0002)
City FE	Yes	Yes	Yes	Yes
State $\times$ Year FE	Yes	Yes	Yes	Yes
Mean(Dep Var)	0.005	0.003	0.003	0.001
N	190,997	190,997	190,997	190,997

Regressions estimated according to Equation 2. Standard errors in parentheses.

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Although the analysis suggests that Mainz did not experience disproportionate growth in the share of firms in industries related to biotechnology among new firms, the time period under consideration might be too short to assess this conclusively. Still, in the immediate aftermath when Biontech's success was particularly salient, there is no evidence of increased cluster creation measured by share of new firms also in the alternative specification in Table 6.

## 5.7 Tax Competition

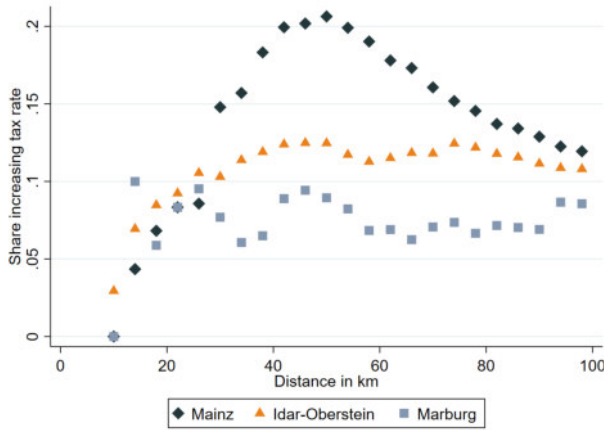
Next, we consider tax rate spillovers to neighboring municipalities, which might have felt pressured to lower their tax rates as well in order to stay competitive for local businesses. Figure 11 focuses on potential tax rate spillovers. Specifically, Figure 11a plots the share of municipalities that increased their business tax rate in 2022, as a function of distance to the respective treated municipality. The three directly affected municipalities decreased their tax rates in 2022 by

4.55 percentage points to 10.85% (Mainz), 3.85 percentage points to 10.85% (Idar-Oberstein) and 1.51 percentage points to 12.50% (Marburg).

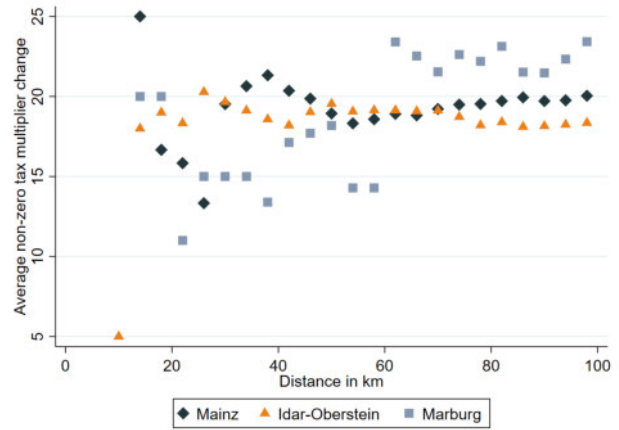
We focus on tax rate increases in neighboring municipalities instead of tax cuts because empirically at the time tax cuts played only a very minor role outside the treated cities. In fact, no municipality closer than 20 kilometers to treated municipalities decreased taxes in 2022. For distances beyond that no clear picture emerges in Figure A45 in the Appendix. Note that the vertical axis is scaled up in comparison to Figure 11a.

The graph in Figure 11a remains descriptive in nature, as a number of factors could confound the share of municipalities increasing taxes. In 2022, there is a positive gradient in the tax hike frequency in terms of distance to the three treated municipalities. Closer municipalities are less likely to increase taxes than those farther away. The gradients are broadly similar for all three municipalities until around 25 kilometers. At this point, municipalities only near Mainz continue to have a higher probability of increasing the more distant they are from Mainz. Reasons for this could be the magnitude of Mainz' tax rate decrease, which was the most substantial among the three, as well as its regional importance.

Figure 11: Business Tax Rate Changes by Radius in 2022



(a) Share of municipalities increasing tax



(b) Average non-zero tax change

Figure A46 in the Appendix repeats this exercise for the year 2019 before COVID-19, when no tax rate changes were implemented in the three municipalities. Here, the hump for Mainz is not present and, if anything, the gradient seems to be reversed in the vicinity of Mainz and Idar-Oberstein, with less frequent tax increases overall. For this reason, it is plausible that the tax rate reductions in treated cities had a moderating effect on tax increases in the neighborhood, which is in line with the presence of local tax competition.

Figure 11b depicts the average tax rate change, conditional on a change taking place. In contrast to Figure 11a there seems to be no clear pattern of a gradient. Instead, irrespective of distance the average tax rate change was around 20 multiplier points, which corresponds to a business tax increase of 0.7 percentage points. Therefore, if there is a tax response at all, it is on the extensive margin instead of the intensive margin. Progressively fewer municipalities in the vicinity of affected municipalities decide to increase taxes. Those that do, however, increase

on average by the same amount as more distant ones.

The reluctance to increase taxes close to tax-cutting municipalities might be explained by the role of advance business tax payment notices. These stipulate a firm’s quarterly tax payment. In case of a tax rate change, the notices need to be altered to reflect the new tax rate and municipalities are obliged to send these out to all local taxpayers. This procedure makes tax rate increases, even very small ones, extremely salient to taxpayers. Taxpayers, in turn, might be more likely to look for alternative locations if their attention is drawn to the local tax increase, but might otherwise be rather oblivious to the surrounding tax environment such as Mainz’ dramatic tax cut. This might also be reflected in the lack of documented discussions in municipal councils surrounding their neighbor’s tax cut. The dominant response to the tax cuts might thus have been to let sleeping dogs lie.

Table 7: Business Tax Multiplier within 20 km vs Outside

	Mainz		Idar-Oberstein		Marburg	
	(1)	(2)	(3)	(4)	(5)	(6)
	All	Same state	All	Same state	All	Same state
Distance<20 km×Year 2022	-3.11*	-5.06**	0.73	0.73	-1.80	-1.80
	(1.41)	(1.61)	(0.96)	(0.97)	(2.49)	(2.49)
Distance<20 km×Year 2023	-5.08**	-7.35**	-3.41*	-3.48*	1.36	1.36
	(1.78)	(2.32)	(1.47)	(1.50)	(4.23)	(4.23)
City FE	Yes	Yes	Yes	Yes	Yes	Yes
State×Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Mean(Dep Var)	373	367	372	372	379	379
N	1,136	744	2,640	2,592	408	408

Regressions estimated according to Equation 2. Standard errors in parentheses.

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

This spillover result is corroborated by regression evidence in Table 7 where the dependent variable is the business tax multiplier. It incorporates a counterfactual tax multiplier development by using an alternative version of the empirical design introduced in Equation (2): Here, the difference-in-differences estimator compares business tax multipliers in 2022 and 2023, respectively, to 2016-2021 of close municipalities (center closer than 20 kilometers) to municipalities beyond this radius (radius between 20 and 30 kilometers). As both areas are of comparable size, the number of observations in the spillover treatment and control group is roughly equal. This is done for each treated municipality individually, including all neighboring municipalities within the outlined area and, as a robustness check, including only those municipalities in this area belonging to the same state as the respective treated region. The samples are visualized in the map in Figure 3.

Compared to the years before 2022 and municipalities beyond the 20 kilometer radius, municipalities close to Mainz exhibit a significant, negative effect on the tax multiplier, i.e. the combination of the intensive and extensive margin response. The effect is more pronounced for 2023 compared to 2022, possibly due to tax adjustment frictions. The null hypothesis of equality, however, cannot be rejected at the conventional levels in Column 1 and 2. The



estimate of -7.35 percentage points in Column 2 for year 2023 corresponds approximately to a 0.26 percentage point lower business tax rate. As pointed out above, this is driven by less increases rather than more decreases compared to the control group.

Forgone tax increases as a response to tax cuts materialize only in 2023 close to Idar-Oberstein. In both Column 3 and 4, equality of coefficients can be rejected at the 1% level. A plausible explanation is the timing of decision to decrease the local business tax multiplier only at the end of 2021, leaving neighboring municipalities little time to respond in 2022.

Overall, spillovers are very limited, even for Mainz and Idar-Oberstein. We estimate a very modest spillover response in relation to the large tax rate decreases. The average spillover response of -7.35 percentage points in 2023 in Column 2 represents only 5.6% of Mainz' tax decrease by 130 percentage points. However, fewer municipalities making changes to their tax rate in the vicinity might make a real difference in terms of tax competition through the outlined salience mechanism even at low spillover estimates.

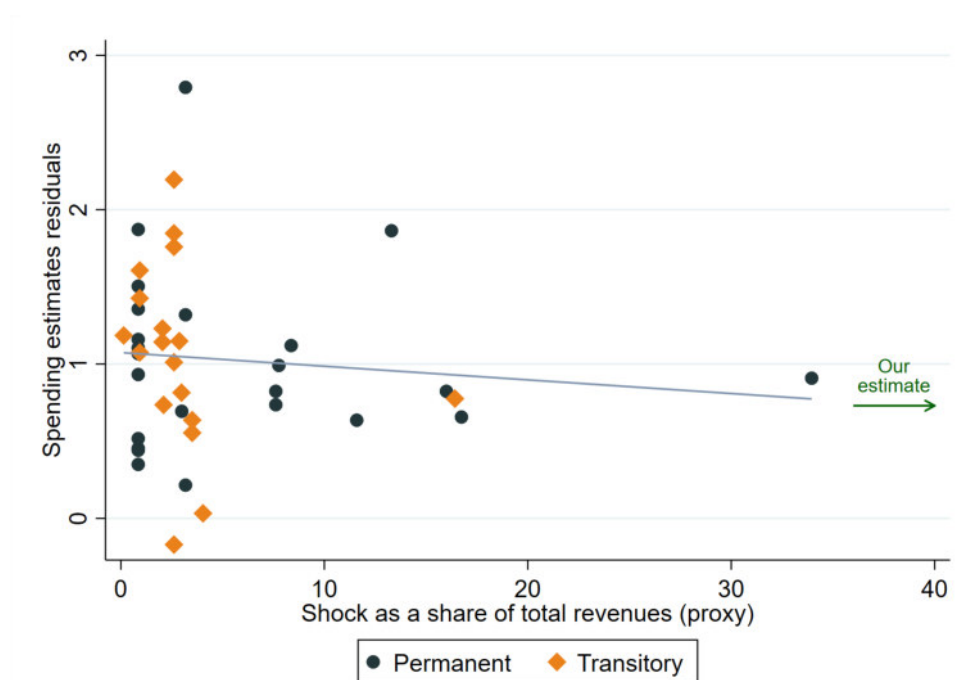
## 6 Implication of the Findings

### 6.1 External Validity

To corroborate the results in this study, we compare the spending response to those found in a non-exhaustive survey of the literature on the effects of local government budget shocks. To that end, we collect 45 causally identified spending estimates from 22 studies as well as the main budget shock and study characteristics. These include the respective budget shock permanence, timing, sign, source (such as intergovernmental grants), a proxy for the shocks' size (share of the total budget and local government level). Spending estimates are normalized to correspond to the per capita change in local currency relative to a 1 unit local currency budget shock.

We document a negative relationship between spending response and size of the shock where a smaller proportion is spent the larger the shock. This insight is revisited in Figure 12, which plots residuals of a regression in the form of Column 7 of Table A8, excluding shock share, against the shock share of total revenues. It distinguishes estimates by their persistency (as viewed by the study authors). There is a wide dispersion of estimates at the low end of shock sizes, while larger shocks, though fewer in number, concentrate closer to 1. The gray line represents a linear fit and implies a slight negative slope. Our spending estimate is comparable to the literature of 0.73 (1-0.27 in capital reserves in Figure A3) at a shock size of a staggering 130% of total revenues, would fit into the overall picture of the literature's estimates (though not precisely the linear fit). Stripping our estimate further of mechanical elements - such as fiscal equalization payments, or intertemporal resource shifting such as debt repayment - reduces it to a mere 0.18 that is actively spent. Since in the literature expenditure items are rarely disaggregated to the degree we are able to do, the comparative analysis remains at this aggregated level. Note that these numbers compare expenditures only to the revenue that materialized in the budget instead of the revenue that could have materialized absent the tax

Figure 12: Spending Response Residuals



**Notes:** This graph depicts residuals of expenditure estimates from the local public finance literature as a function of shock size, i.e. shock share of total public , and a linear fit. Expenditure estimates are residualized according to Column 7 of Table A8. The graph distinguishes between shocks that are considered permanent and transitory by the authors. Our estimate represents a shock of around 130% of total revenues and 73% of the shock is spent in the same year.

rate cuts. Since the latter would have been larger, this would attenuate spending response estimates further.

What are implications and lessons from the Biontech shock? Although the sheer size of the shock seems to be somewhat of an outlier, our estimates of the fiscal responses are not far from other, more moderate estimates found in the literature. On top of this, municipalities not only in Germany often find themselves in the position of hosting one dominant business, opening themselves up to the same opportunities, incentives and dependencies studied in this paper (cf. Table A7). This shock’s magnitude can help to accentuate prevalent mechanisms.

## 7 Conclusion

We study the effect of a sudden tax revenue windfall caused by the firm Biontech in three municipalities. To this end, we collected detailed budget data including current and preliminary figures. Affected municipalities dramatically decreased their local tax rates. Despite this, public budgets approximately doubled in the years after the Biontech shock. Much of the excess revenue was used to reduce debt and build up capital reserves, which, unlike the tax cut, is in line with smoothing the revenue over many fiscal years. The extra revenue translated eventually into a change in the status of the fiscal equalization system from net beneficiary to net contributor.

Beyond public finances, there is scant evidence that Mainz was able to build on this one-off success. We find no effect of more business entries, but document that less firms relocate away or shut down after the tax cut. Up until 2024, there is no evidence for an increase in the share of life-sciences firms among new firms, disappointing hopes that a whole cluster of biotechnology firms would emerge.

In terms of tax competition, neighboring municipalities response was subtle, mainly decreasing the probability to increase the tax rate at all as opposed to increasing it by less. This limited response could be explained by pure necessity during a pandemic or municipalities’ anticipation that tax cuts are temporary. Indeed, two municipalities directly affected by the Biontech shock have already increased its rate back to pre-shock levels in 2024 and 2025 respectively.

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# Appendix

## A Budget Item Description

Budget Item	Description
<i>Municipal Revenues</i>	
<b>Tax Revenues</b>	Contains all tax payments to municipalities from income, value-added, local business and property tax, and other minor municipal taxes.
<b>Transfer, levy and grant revenues</b>	Revenues from fiscal equalization schemes.
<b>Welfare revenues</b>	Direct welfare-earmarked transfers from state and federal levels.
<b>Public-oriented fees</b>	Fees for administrative processes.
<b>Privated-oriented fees</b>	Childcare fees, cemetery fees, etc.
<b>Interest Revenue</b>	Revenues from interest payments.
<i>Municipal Expenditures</i>	
<b>Staff and personnel expenditure</b>	Expenditures on staff and personnel-related costs.
<b>Service expenditure</b>	Spending on material, energy costs, maintenance of municipal assets.
<b>Transfer, levy and grant expenditures</b>	Payments into the fiscal equalization system, transfers to local associations.
<b>Welfare Spending</b>	Payouts of welfare spending that is carried out by municipalities (payments to refugees, housing and heating subsidies, disability payments).
<b>Interest Expenditure</b>	Expenditures on interest payments.
<b>Public Investment Expenditures</b>	Spending on public infrastructure and capital projects.
<b>Capital Reserves</b>	Reserves held for investment or emergency purposes.
<b>Investment Loans</b>	Specific loans that can only be used to finance public investment.
<b>Cash-loans</b>	Loans taken out by municipalities designed to meet short-run liquidity constraints.

**Note:** From municipal balance sheets, we collect the stock variables capital reserves, investment loans and cash-loans. Investment loans are specific loans that can only be used to finance public investment, while cash-loans are taken out by municipalities to meet short-term liquidity needs.

## B Local Public Finance

Besides revenues from the local business taxes, German municipalities receive 15% of national income tax revenue and 2% of national value-added tax revenue. These make up around 38% of overall municipal tax revenue. The property tax, whose tax multiplier is also set by municipalities, plays a relatively small role compared to other revenue sources. The biggest source of revenues for municipalities in general are transfers from the municipal fiscal equalization scheme (Federal Statistical Office (2023)).<sup>6</sup>

While some municipal spending is mandated by state and federal government (e.g. welfare spending), municipalities enjoy considerable autonomy in other areas of public policy. For instance, childcare and maintaining public schools are municipal responsibilities. The extent and quality at which these public services are provided is largely left to municipalities. Other areas, such as cultural and recreational activities, are fully optional. Moreover, German municipalities carry out around 55% of public investment in Germany (Federal Statistical Office, 2023). Hence, gaining insights into the marginal propensity of public investment is important for policymakers, who want to boost public investment.

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<sup>6</sup>While these systems are designed by each state individually, its mechanics are widely similar: On an annual basis, the state governments defines<sup>DR</sup> an amount that is to be redistributed across municipalities according to a pre-defined formula. This formula weighs fiscal need (mostly measured by the number of inhabitants) against fiscal strength (a combination of tax revenues). If fiscal need exceeds fiscal strength, the difference is compensated to some extent. So-called “abundant” municipalities, whose fiscal strength is larger than their need, receive nothing and sometimes contribute to the overall amount to be redistributed through municipal levies. If cities experience windfall tax gains like the three firm sites of Biontech, their fiscal strength shoots up and are likely to become abundant and hence a net contributor to the fiscal equalization system.

## C Descriptive Statistics

Table A1: Descriptive Statistics: Before Treatment (Averages 2016-2020)

	Treatment Group		Control Group		Mean Difference	
	Mean	SD	Mean	SD	Difference	t-statistic
<b>Revenues per capita (€)</b>						
Total Revenue	2645.12	497.65	3000.31	1521.13	355.19	(1.68)
Tax Revenue	1389.67	306.84	1743.05	1504.42	353.38*	(2.07)
Transfer Revenue	518.34	149.95	544.11	310.68	25.77	(0.46)
Welfare Revenue	289.47	172.57	357.23	261.06	67.76	(1.13)
Public-related Fees	76.46	16.30	99.39	47.25	22.93**	(3.38)
Private-related Fees	43.55	16.24	69.95	50.29	26.40***	(3.80)
Interest Revenue	31.55	29.92	44.20	77.81	12.65	(1.06)
<b>Current Spending per capita (€)</b>						
Total Expenditures	2543.48	446.40	2722.48	1183.65	179.00	(1.00)
Staff and Personnel Expenditures	742.97	120.60	761.69	174.31	18.72	(0.45)
Service Expenditures	262.53	62.32	376.38	129.30	113.86***	(4.93)
Welfare Expenditures	766.33	419.89	623.50	521.97	-142.83	(-1.01)
Transfer Expenditures	594.44	122.07	808.76	1167.31	214.32	(1.86)
Interest Expenditures	117.53	18.18	75.53	62.84	-42.00***	(-5.12)
Public Investment	241.01	118.50	355.37	311.07	114.36*	(2.41)
<b>Balance sheet per capita (€)</b>						
Liquidity loans	3099.86	270.48	1738.81	2261.79	-1361.06***	(-5.98)
Investment loans	1824.99	772.84	1233.85	732.12	-591.14*	(-2.33)
Capital Reserves	1961.74	2258.95	4528.79	4425.77	2567.05**	(3.11)
Population	123199.20	98136.67	51217.58	39956.13	-71981.62*	(-2.30)
Observations	10		115		125	



Table A2: Descriptive Statistics: After Treatment (Averages 2021-2024)

	Treatment Group		Control Group		Mean Difference	
	Mean	SD	Mean	SD	Difference	t-statistic
<b>Revenues per capita (€)</b>						
Total Revenue	7562.99	2492.05	3480.97	1228.65	-4082.02**	(-4.58)
Tax Revenue	5136.96	2435.56	1930.18	1165.46	-3206.78**	(-3.69)
Transfer Revenue	506.15	213.34	720.68	382.80	214.52*	(2.51)
Welfare Revenue	377.02	231.39	418.34	313.38	41.31	(0.47)
Public-related Fees	89.87	22.06	116.28	53.35	26.41*	(2.76)
Private-related Fees	46.45	17.28	80.83	74.43	34.38**	(3.48)
Interest Revenues	37.61	31.60	28.16	34.40	-9.45	(-0.81)
<b>Current Spending per capita (€)</b>						
Total Expenditures	5159.80	2494.02	3329.91	1340.21	-1829.89	(-2.05)
Staff and Personnel Expenditures	1212.76	553.50	1001.39	223.05	-211.37	(-1.07)
Services Expenditures	409.06	112.82	510.17	169.95	101.11*	(2.32)
Welfare Expenditures	936.93	603.19	695.14	582.81	-241.79	(-1.09)
Transfer Expenditures	2068.46	1955.91	882.75	1142.17	-1185.71	(-1.69)
Interest Expenditures	128.38	117.80	70.85	60.64	-57.53	(-1.37)
Public Investment	636.36	406.41	623.25	378.53	-13.11	(-0.09)
<b>Balance sheet per capita (€)</b>						
Liquidity loans	650.63	336.26	1510.76	2151.47	860.13**	(3.39)
Investment loans	1477.19	1303.80	1713.84	1064.81	236.66	(0.50)
Capital Reserves	4432.95	4693.49	4562.09	4391.49	129.14	(0.08)
Population	127128.63	103398.78	52245.05	40718.29	-74883.57	(-2.03)
Observations	8		92		100	

# D Expenditure Response

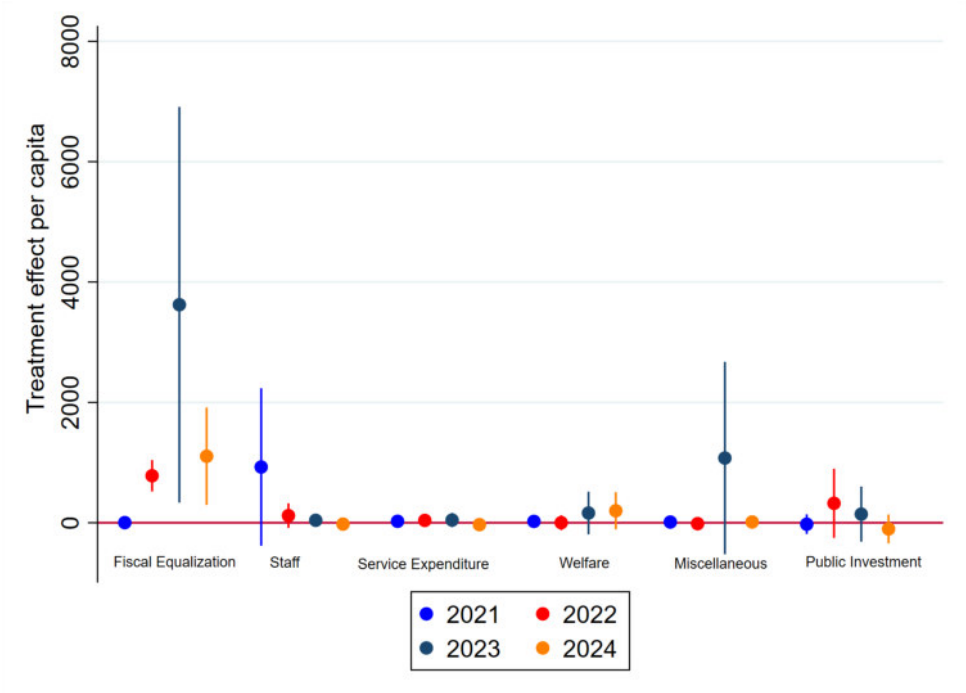


Figure A1: Caption

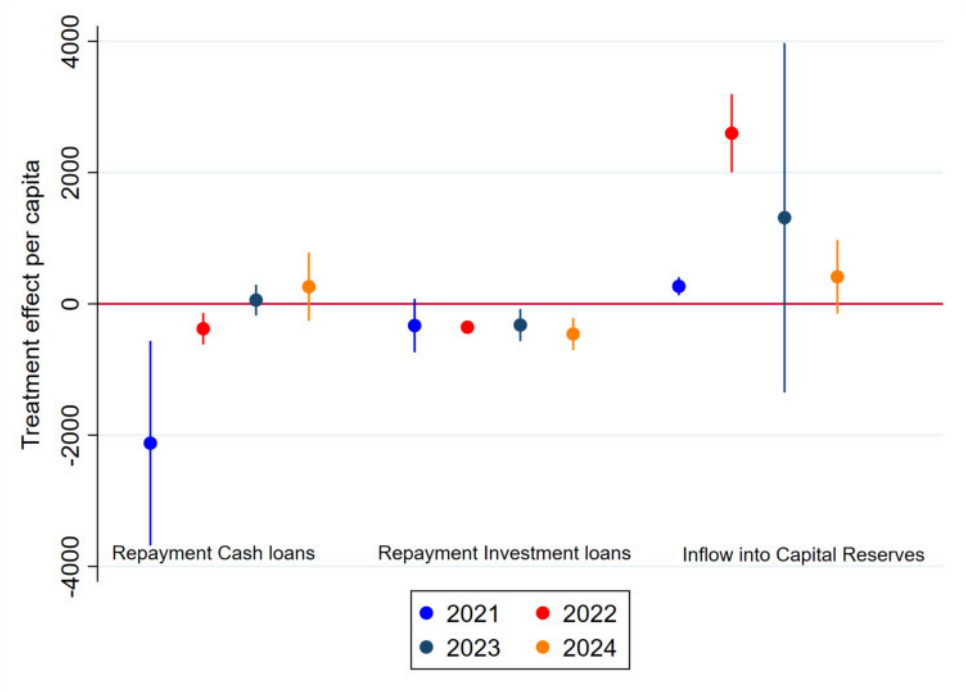
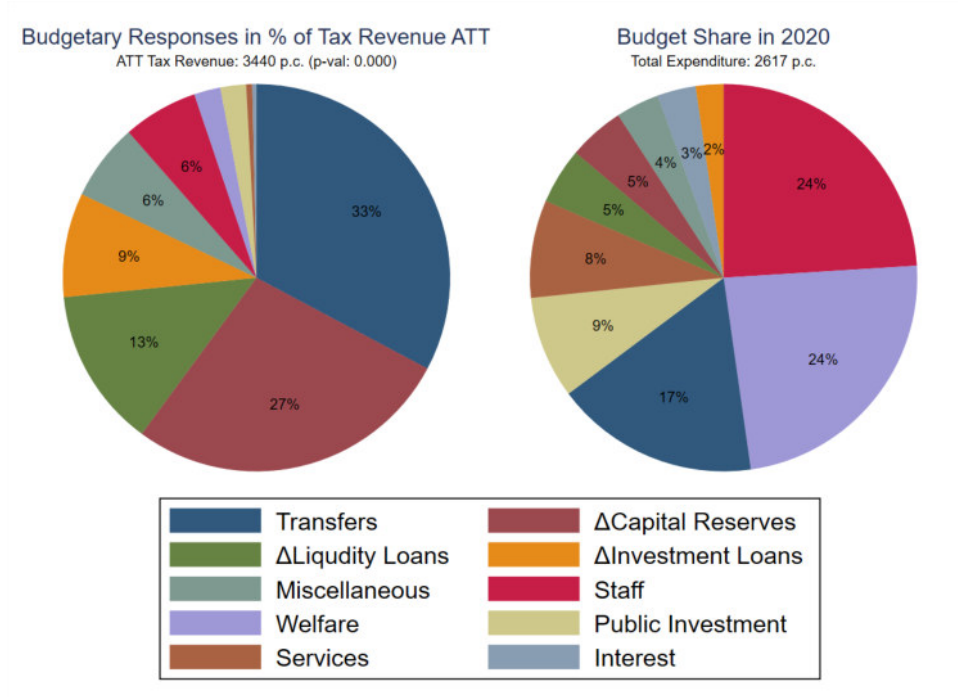


Figure A2: Caption

Figure A3: Budgetary Response Breakdown



**Notes:** This Figure shows 2020 budget shares (right-hand graph) and estimates (left-hand graph) of the reallocation of municipal expenditures to the windfall tax revenues from the Biontech shock, using a synthetic difference-in-differences (SDID) approach. Results show that approximately 50% of the revenue gains were allocated to debt repayment and capital reserve increases, while discretionary spending, such as public investment, showed insignificant changes. Respective p-values are presented in Tables A3 and A4 in the Appendix.

Table A3: Current Spending

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Transfer	Miscellaneous	Welfare	Service	Staff Expenditure	Public Investment	Interest Expenditure
Share	32.78%	6.43%	2.20%	0.50%	6.26%	2.15%	0.35%
p-value	0.012	0.182	0.38	0.456	0.066	0.518	0.614

Table A4: Balance Sheet Categories

	(1)	(2)	(3)
	Inflow	Liquidity Loan	Investment Loan
	Capital Reserves	Repayment	Repayment
Share	27.31%	13.30%	8.72%
p-value	0.018	0.000	0.000

D.1 Synthetic DiD: Event Study plots (both municipalities)

Municipal Revenue:

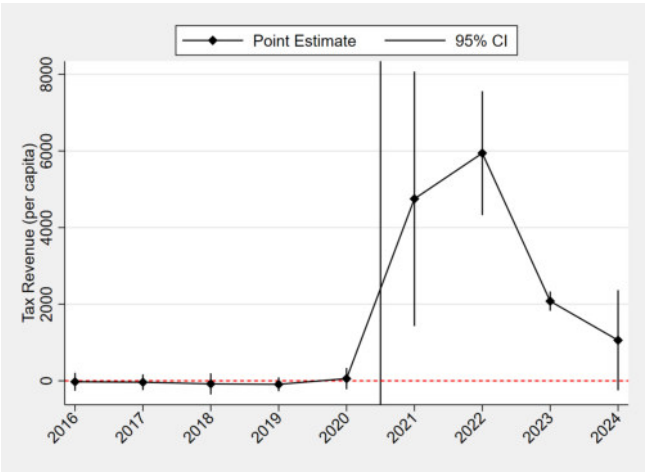


Figure A4: Tax Revenues

(Current) Expenditure:

Figure A5: Staff Expenditure

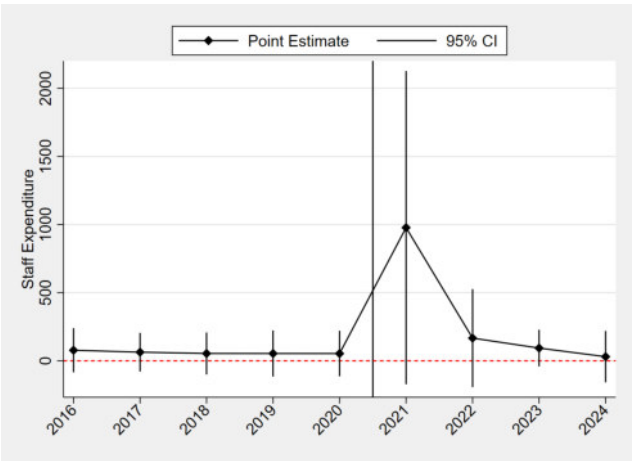


Figure A6: Transfer Expenditure

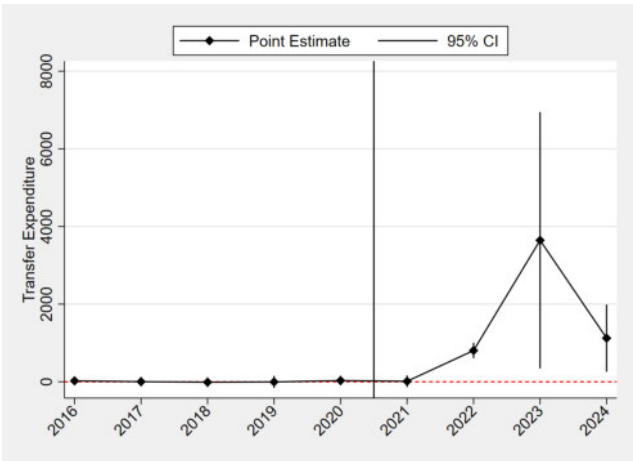


Figure A7: Service Expenditure

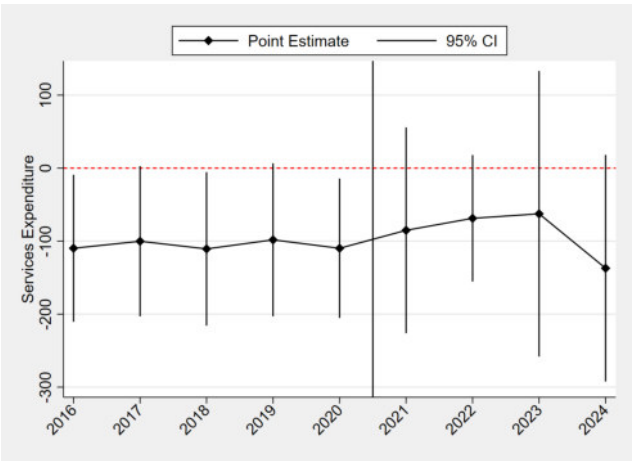
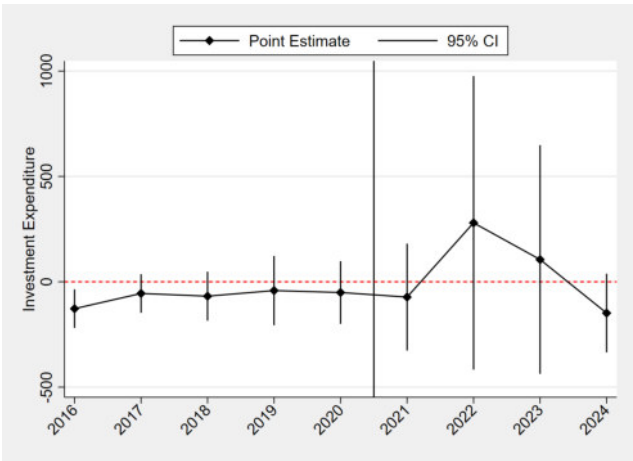


Figure A8: Public Investment



Balance sheet data:

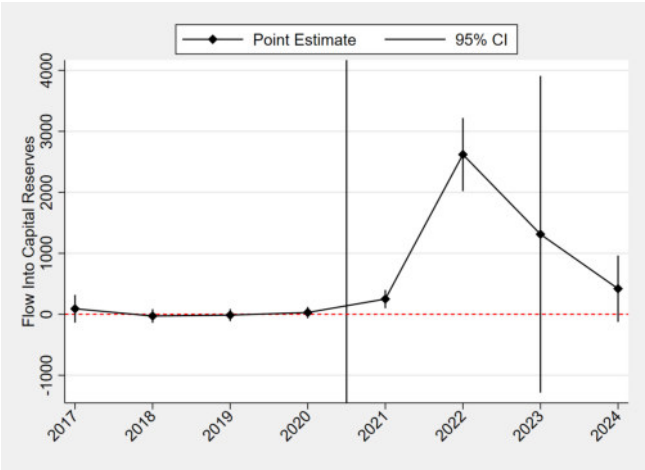


Figure A9: Inflow into capital reserves

Figure A10: Liquidity Loans

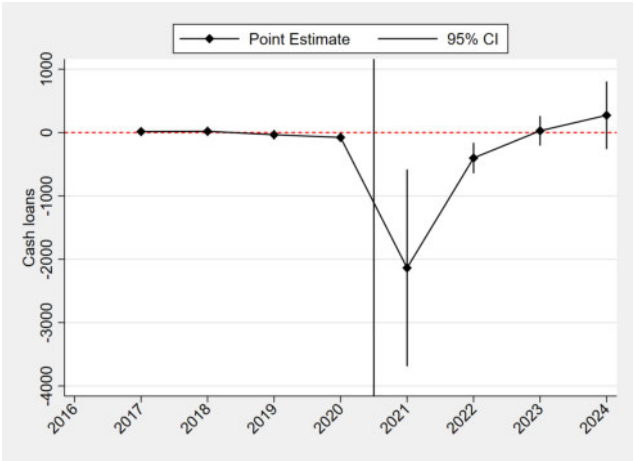
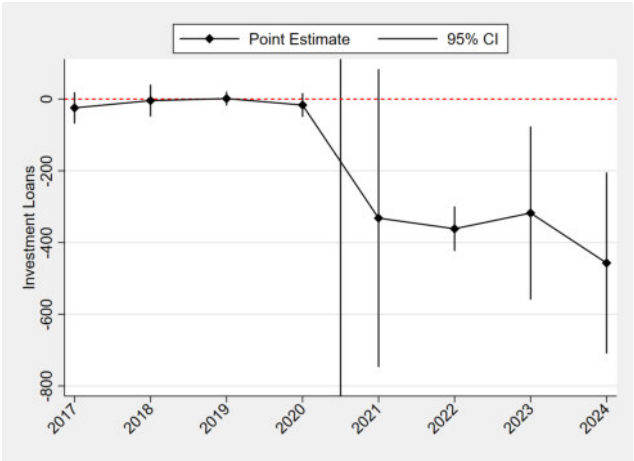


Figure A11: Investment Loans



## D.2 Synthetic DiD: Event Study plots (Mainz)

Municipal Revenue:

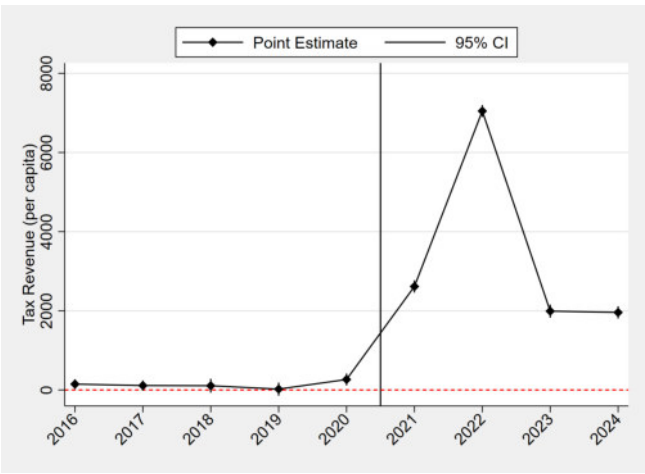


Figure A12: Tax Revenues

(Current) Expenditure:

Figure A13: Service Expenditure

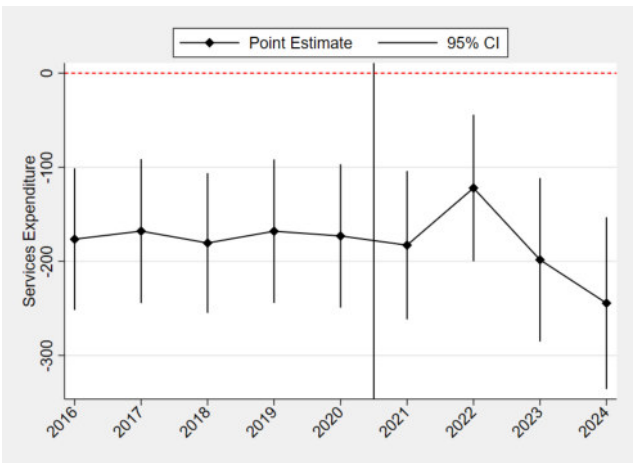


Figure A14: Public Investment

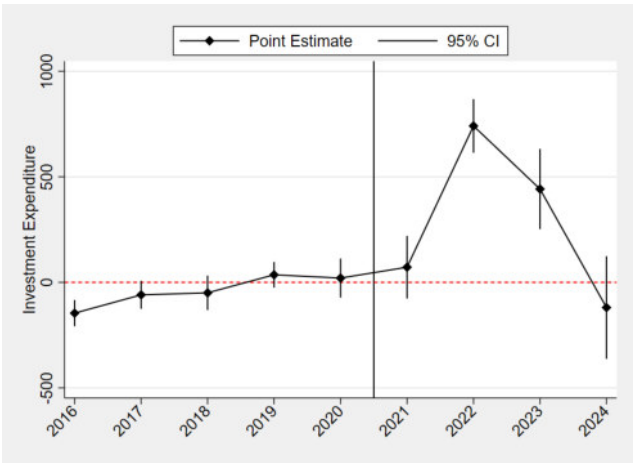


Figure A15: Transfer Expenditure

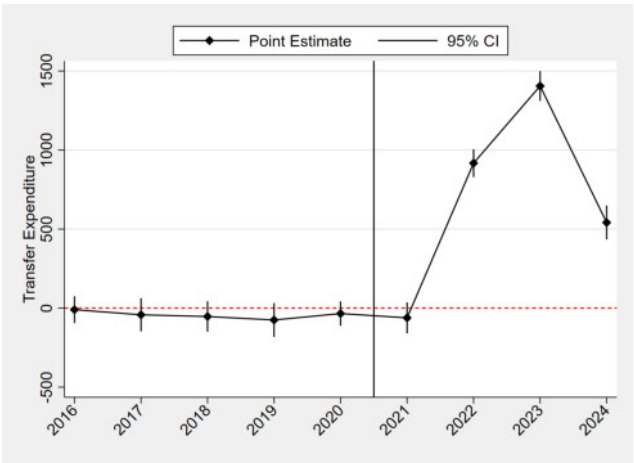


Figure A16: Staff Expenditure

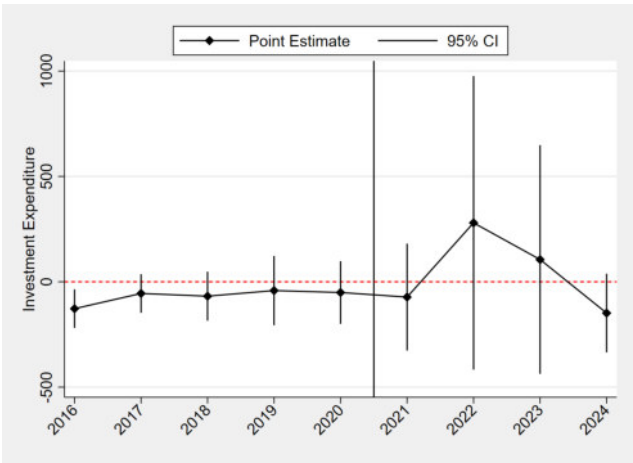


Figure A17: Welfare Expenditure

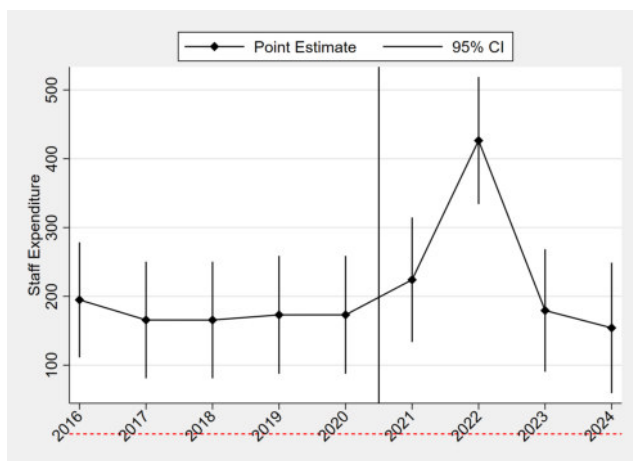
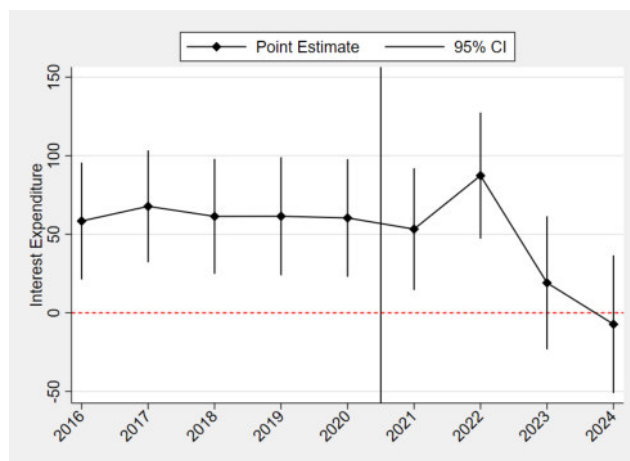


Figure A18: Interest Expenditure



Balance sheet data:

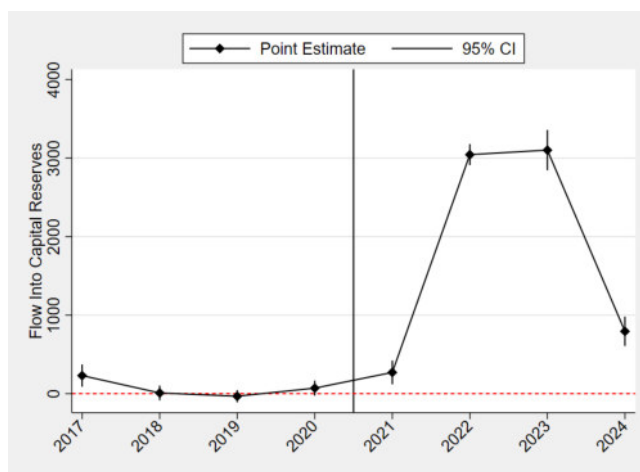


Figure A19: Inflow into capital reserves

Figure A20: Liquidity Loans

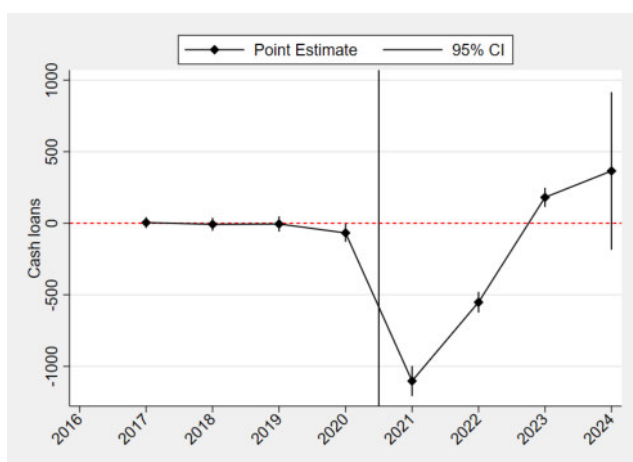
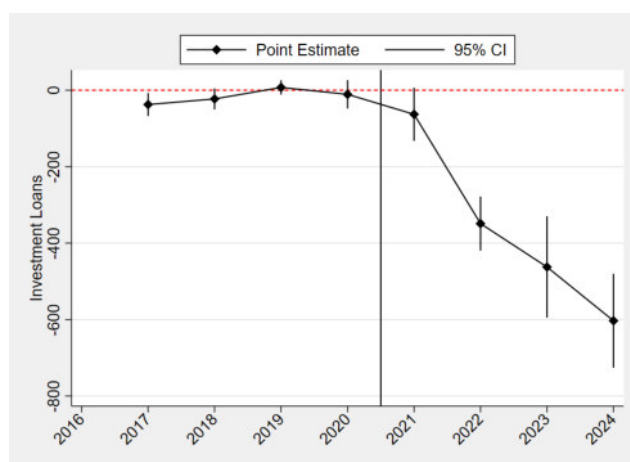


Figure A21: Investment Loans



D.3 Synthetic DiD: Event Study plots (Idar-Oberstein)

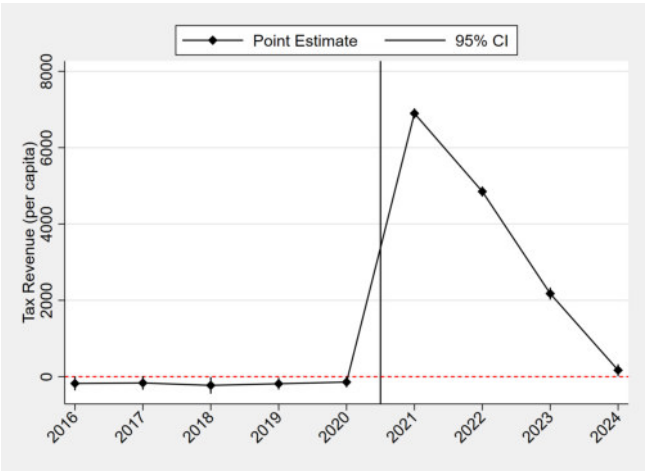


Figure A22: Tax Revenues

(Current) Expenditure:

Figure A23: Service Expenditure

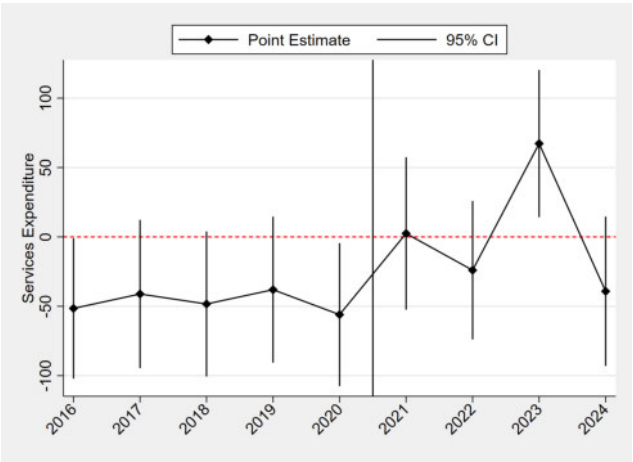


Figure A24: Public Investment

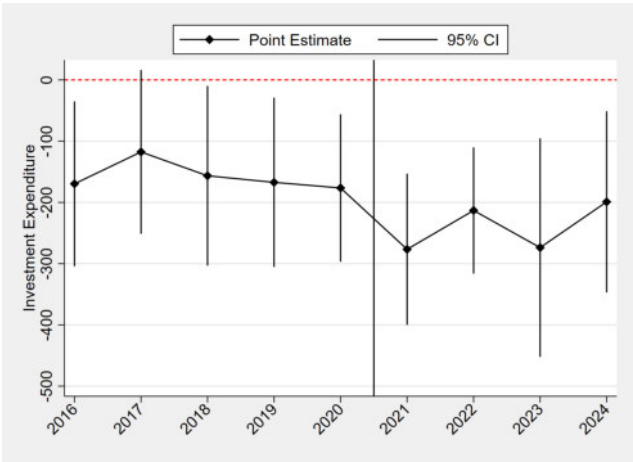


Figure A25: Transfer Expenditure

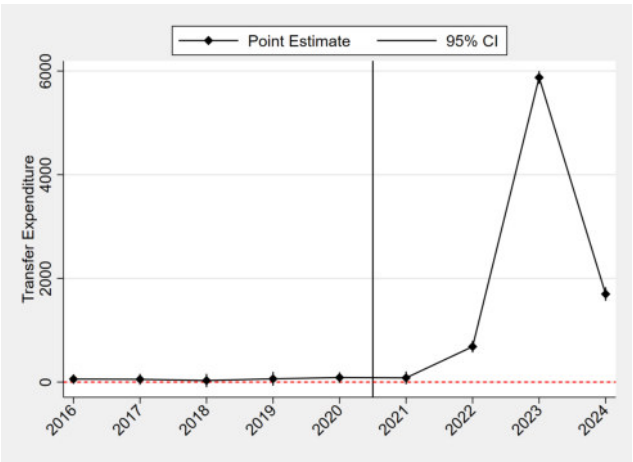


Figure A26: Staff Expenditure

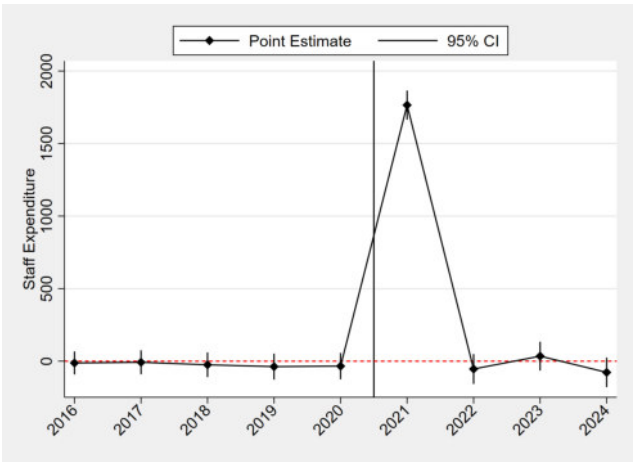




Figure A27: Welfare Expenditure

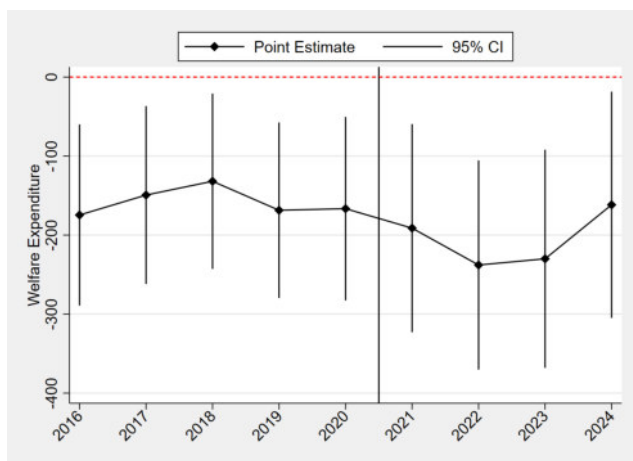
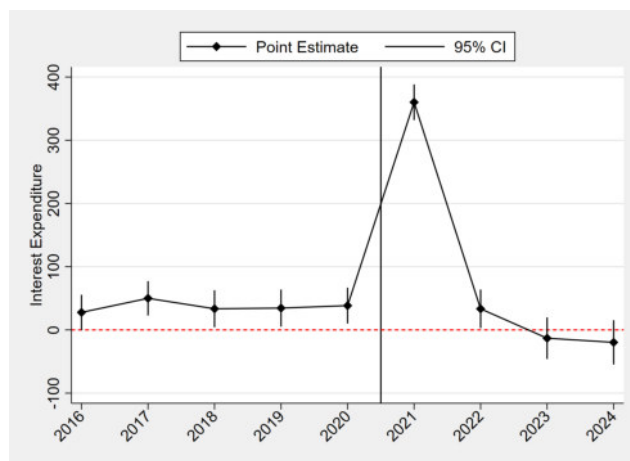


Figure A28: Interest Expenditure



Balance sheet data:

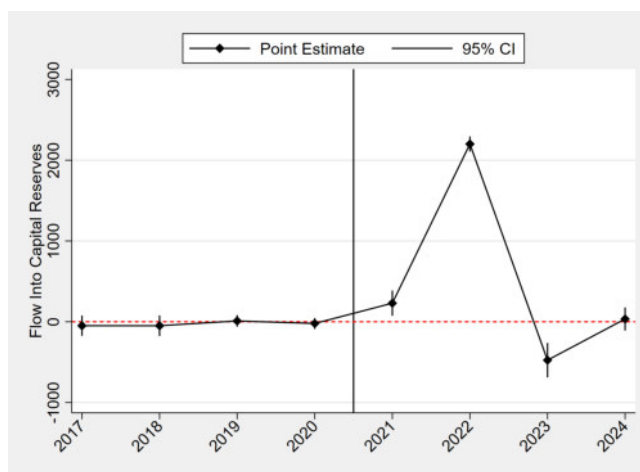


Figure A29: Inflow into capital reserves

Figure A30: Liquidity Loans

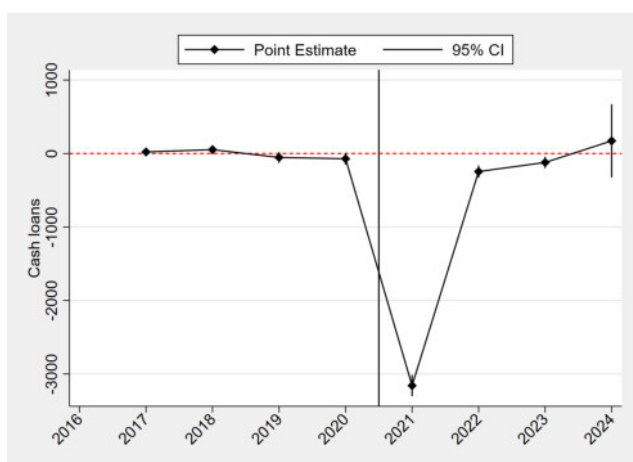
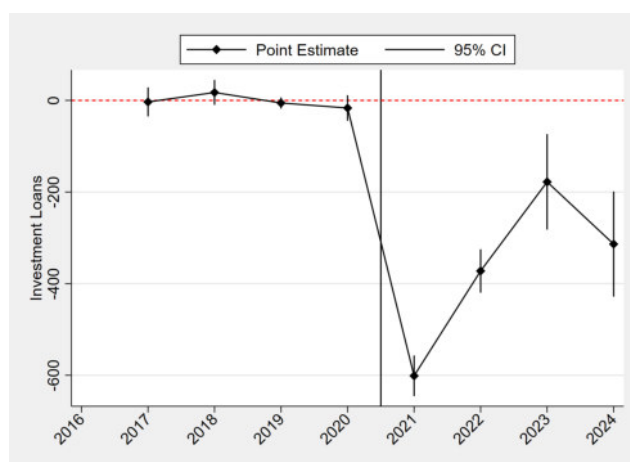
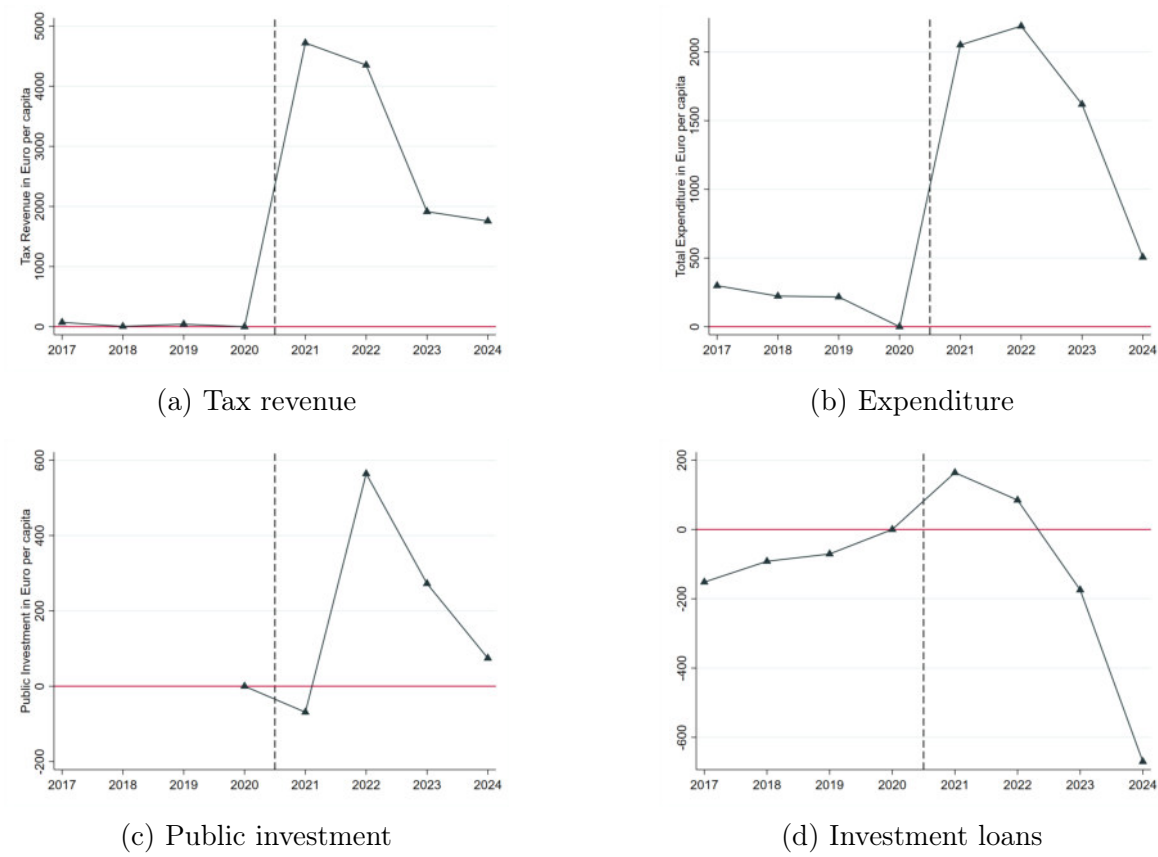


Figure A31: Investment Loans



# D.4 Comparison to Tübingen

Figure A32: Normalized Difference Between Mainz and Tübingen of Selected Budget Items



## E Tax Responses

### E.1 Simple Difference-in-difference

Local Tax Rates in Mainz:

Figure A33: Local Business Tax Rate (Mainz)

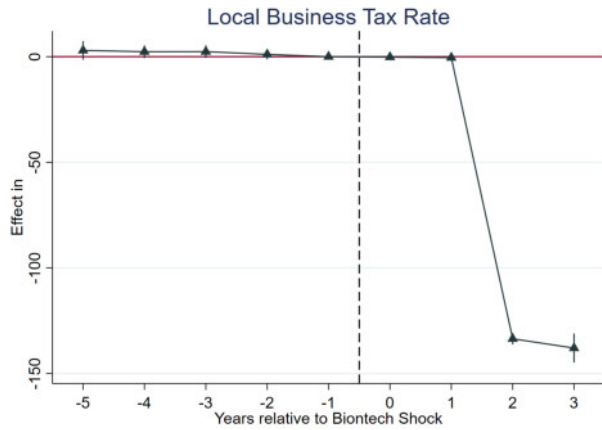
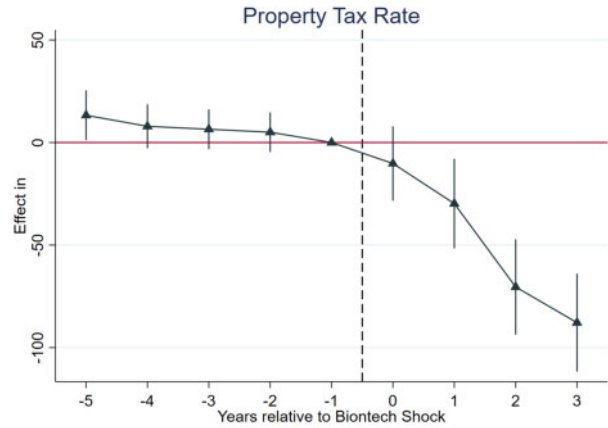


Figure A34: Local Business Tax Rate (Idar-Oberstein)



Municipal Revenue:

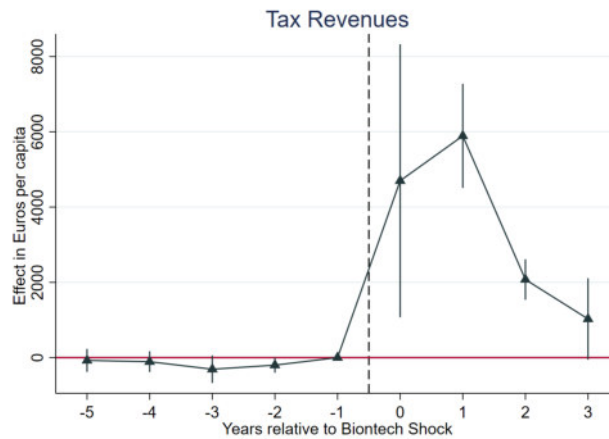


Figure A35: Tax Revenues

(Current) Expenditure:

Figure A36: Total Expenditure

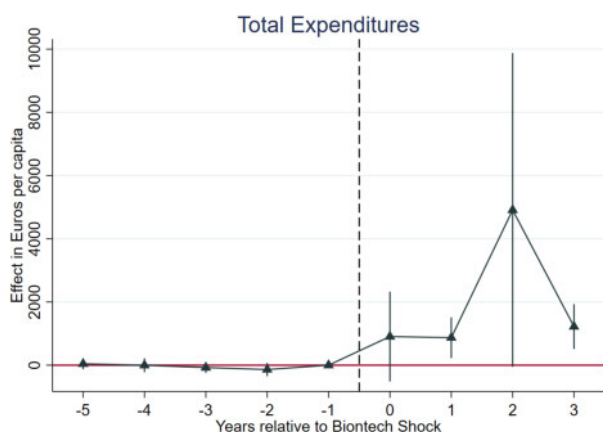


Figure A37: Welfare Expenditure

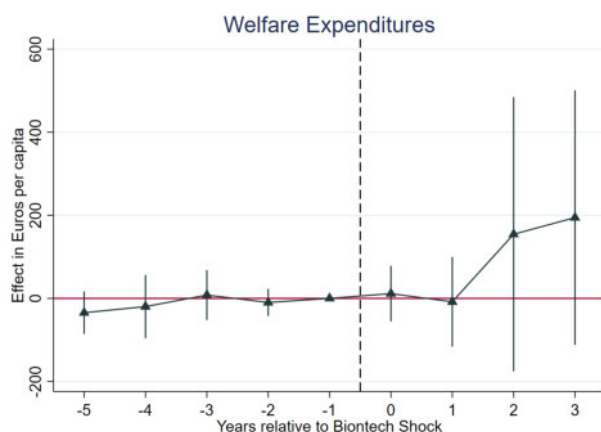


Figure A38: Service Expenditure

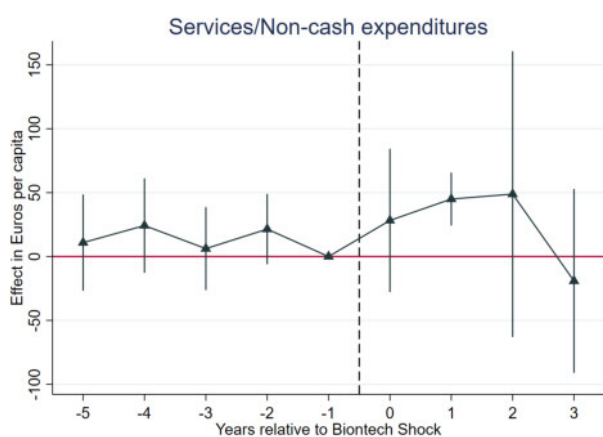


Figure A39: Transfer Expenditure



Figure A40: Interest Expenditure

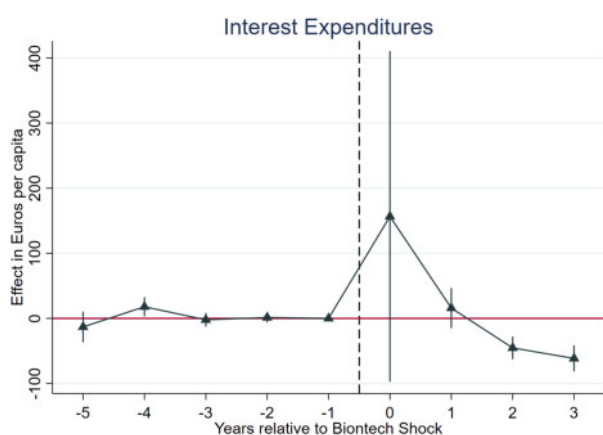
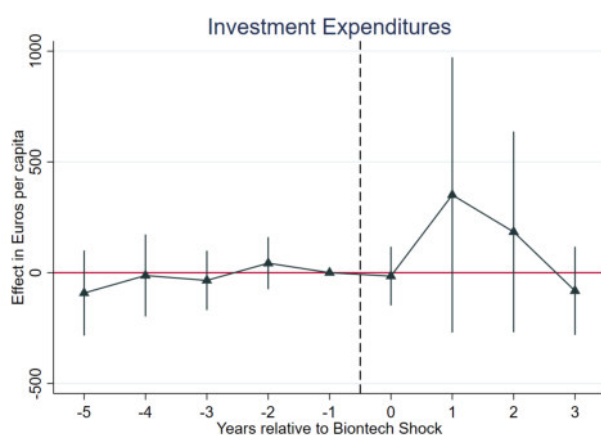


Figure A41: Public Investment



Balance sheet data:

Table A5: Number of new firms in industry 72 per year and municipality

year	Ingelheim	Mainz
2017	1	0
2018	0	4
2019	0	3
2020	0	2
2021	1	4
2022	0	1
2023	0	0
2024	0	0

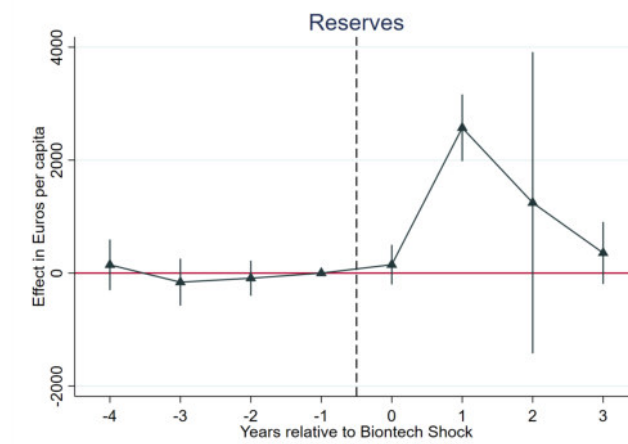


Figure A42: Inflow into capital reserves

Figure A43: Liquidity Loans

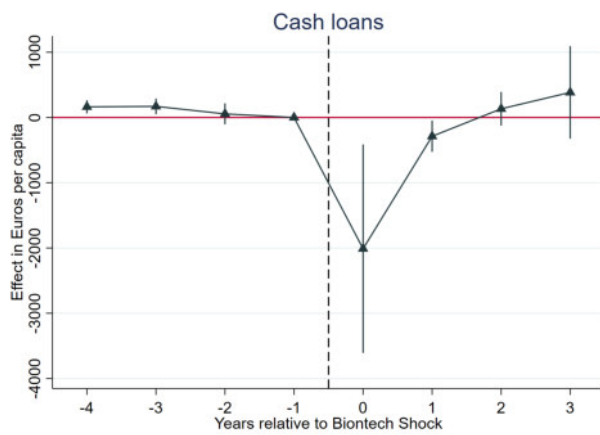
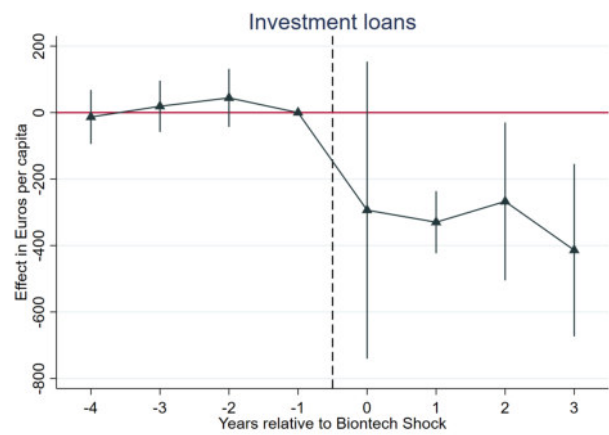


Figure A44: Investment Loans



## F Firm Responses

## G Tax Competition

Table A6: Ingelheim: Industry Share Change among New Firms

	(1)	(2)	(3)	(4)
	NACE 72	NACE 721	NACE 7219	NACE 7211
Ingelheim $\times$ Post 2021	-0.006*** (0.0009)	-0.007*** (0.0007)	-0.003*** (0.0006)	-0.004*** (0.0003)
City FE	Yes	Yes	Yes	Yes
State $\times$ Year FE	Yes	Yes	Yes	Yes
Mean(Dep Var)	0.005	0.003	0.003	0.001
N	190,997	190,997	190,997	190,997

Regressions estimated according to Equation 2. Standard errors in parentheses.

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Figure A45: Share of Municipalities Decreasing Tax in 2022 by Radius

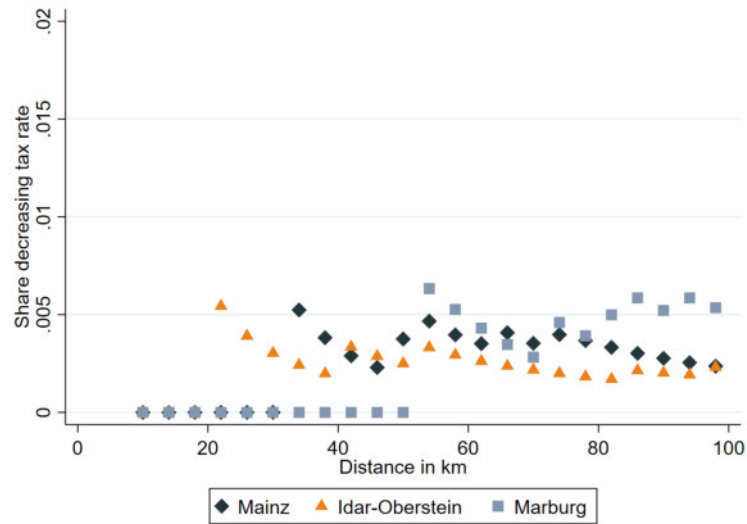
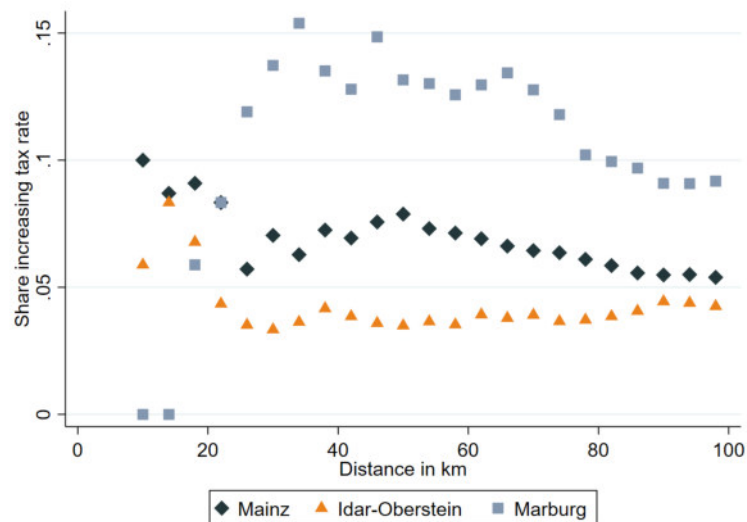


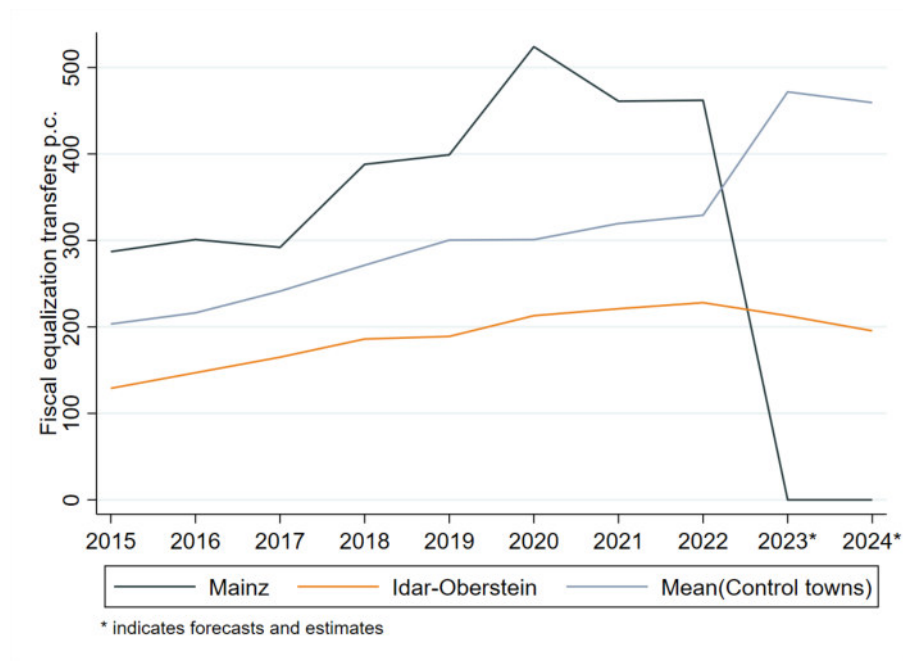
Figure A46: Share of Municipalities Increasing Tax in 2019 by Radius



## H Internal Validity

Figure A47 plots fiscal equalization payments per capita over time for Mainz, Idar-Oberstein and the mean of municipalities in the control group. Payments develop similarly for treated and control cities until 2022. They start to diverge in 2023. Forecast fiscal equalization payments to Mainz collapse to zero and decrease for Idar-Oberstein, but increase substantially on average for control units. The observed delay in divergence is explained by the equalization scheme's provision that fiscal equalization payment are calculated based on data with a lag of up to two years. Thus, a tainted control group is not a major concern for the first two years of the Biontech shock.

Figure A47: Fiscal Equalization Transfers per capita



# I External Validity

Table A7: Prominent Cases of Firms Experiencing Sudden Spikes in Profits

Firms	Location	Circumstances	Timing	Year	Sector
Lilly Elly (Mounjaro)	Minneapolis, US	Development of anti-diabetes medication	Slow	2019+	Health
Novo Nordisk (Ozempic)	Glaxo, Denmark	Development of anti-diabetes medication	Slow	2020+	Health
Zoom	San José, US	Videocommunication, Covid-19 Pandemic	Sudden	2020+	IT
Moderna	Cambridge, US	Covid-19 Vaccine	Sudden	2020+	Health
TeamViewer	Göppingen, Germany	Videocommunication, Covid-19 Pandemic	Sudden	2020+	Military
Rheinmetall	Several cities, Germany	Military equipment to Ukraine	Sudden	2022+	Military
General Dynamics	Several cities, US	Military equipment to Ukraine	Sudden	2022+	Military

Table A8: OLS Standardized spending estimate in currency units per 1 currency unit budget shock

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Permanent (Transitory omitted)									
Yes		0.54 (0.35)	0.46 (0.30)	0.40* (0.22)	0.69*** (0.18)	0.56*** (0.17)	0.60*** (0.15)	0.85** (0.29)	-0.13 (0.25)
Sign (Positive omitted)									
Both			-0.10 (0.37)	-0.24 (0.33)	-0.69* (0.33)	-0.71* (0.35)	-0.54** (0.21)	-0.52 (0.35)	0.03 (0.02)
Negative			-0.82** (0.31)	-0.46 (0.37)	-0.19 (0.18)	-0.23 (0.20)	-0.12 (0.21)	-0.26 (0.27)	0.06 (0.04)
Shock source (Tax revenues omitted)									
Atypical revenues				-0.35 (0.24)	-0.23 (0.27)	-0.23 (0.28)	-0.33 (0.31)	-0.53*** (0.17)	-1.76*** (0.34)
Grant				0.60** (0.25)	0.88*** (0.20)	0.88*** (0.19)	0.84*** (0.26)	0.78* (0.40)	0.00 (.)
Continuous variables									
Shock share of total revenues					-0.05** (0.02)	-0.04** (0.02)	-0.02 (0.01)	0.01 (0.01)	-0.01 (0.04)
Effect time in years						0.04 (0.05)	0.06 (0.04)	0.07 (0.05)	0.05 (0.06)
Level of govt (Muni omitted)									
County							-0.42 (0.27)	-0.97 (0.65)	
School district							-1.06*** (0.28)	-1.77*** (0.26)	0.00 (.)
Constant	1.01*** (0.22)	0.73*** (0.25)	0.90*** (0.27)	0.57** (0.20)	0.59** (0.20)	0.55** (0.19)	0.45 (0.26)		
Country FE	No	No	No	No	No	No	No	Yes	No
Paper FE	No	No	No	No	No	No	No	No	Yes
N	45	45	45	45	42	42	42	40	33

Standard errors in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < .01$



Table A9: WLS Standardized spending estimate in currency units per 1 currency unit budget shock

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Permanent (Transitory omitted)									
Yes		0.13 (0.37)	0.13 (0.32)	-0.12 (0.26)	0.14 (0.39)	0.08 (0.32)	0.32*** (0.09)	0.55** (0.18)	-0.20 (0.21)
Sign (Positive omitted)									
Both			-0.29 (0.27)	-0.22 (0.28)	-0.37 (0.30)	-0.37 (0.30)	-0.09 (0.09)	-0.02 (0.05)	0.01*** (0.00)
Negative			-0.52** (0.23)	-0.11 (0.17)	-0.23 (0.20)	-0.23 (0.22)	-0.01 (0.05)	0.01 (0.03)	0.03*** (0.00)
Shock source (Tax revenues omitted)									
Atypical revenues				-0.64*** (0.17)	-0.48 (0.41)	-0.44 (0.50)	-0.24* (0.12)	-0.51 (0.38)	8.52* (3.51)
Grant				0.04 (0.27)	0.18 (0.38)	0.21 (0.44)	0.61*** (0.07)	0.66*** (0.12)	0.00 (.)
Continuous variables									
Shock share of total revenues					-0.03 (0.03)	-0.03 (0.03)	-0.01 (0.01)	0.01 (0.02)	1.35** (0.49)
Effect time in years						0.02 (0.07)	0.06* (0.03)	0.05 (0.06)	0.07 (0.05)
Level of govt (Muni omitted)									
County							-0.10 (0.20)		
School district							-1.25*** (0.06)	-1.51*** (0.12)	0.00 (.)
Constant	0.71*** (0.19)	0.66** (0.22)	0.82*** (0.23)	1.06*** (0.27)	1.04*** (0.32)	0.99** (0.45)	0.50*** (0.15)		
Country FE	No	No	No	No	No	No	No	Yes	No
Paper FE	No	No	No	No	No	No	No	No	Yes
N	38	38	38	38	36	36	36	34	29

Standard errors in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < .01$