Tax and Vax:

The Fiscal and Economic Effects of the BioNTech Shock

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Abstract

We study how local governments respond to a large and unexpected revenue windfall under uncertainty about its persistence. Exploiting quasi-experimental variation from BioNTech's COVID-19 vaccine breakthrough, we analyze German municipalities that received unprecedented local business tax revenues. Despite the surge, municipalities did not expand discretionary spending relative to a control group; current expenditure and public investment remained stable. Instead, they repaid debt, accumulated reserves, and temporarily reduced local business and property tax rates. These tax cuts reflected initially optimistic expectations and were reversed as revenues declined, highlighting how uncertainty and balanced-budget rules constrain intertemporal fiscal adjustment even amid exceptionally strong balance sheets.

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

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

1 Introduction

Local governments regularly face fluctuations in revenues, yet their responses to fiscal shocks remain imperfectly understood. A large empirical literature studies how subnational governments adjust spending and taxation in response to changes in intergovernmental transfers or tax bases, often exploiting plausibly exogenous variation in institutional rules or policy reforms (e.g., Dahlberg et al., 2008; Helm and Stuhler, 2024). This research has yielded important insights, but is largely based

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on the analysis of shocks that are moderate in size or predictable in timing. Much less is known about how governments respond to extreme and unexpected revenue windfalls—particularly when the persistence of shocks is highly uncertain.

This aspect matters for both theory and policy. Standard intertemporal public finance models predict that governments should smooth spending in response to transitory shocks while primarily adjusting taxes in response to permanent changes (cf. Barro, 1979). In practice, however, policymakers must make decisions before the persistence of a shock is known and under institutional constraints (such as fiscal rules and fiscal oversight) that may limit intertemporal smoothing. As emphasized by Poterba (1994), balanced-budget requirements and fiscal oversight bodies can force rapid adjustment to adverse shocks, but their implications for positive shocks that allow for discretionary spending increases and tax cuts are less well understood.

This paper studies a rare fiscal episode that allows us to address this issue: the dramatic surge in municipal business tax revenues following BioNTech's breakthrough in developing an effective COVID-19 vaccine. The shock was very large and plausibly exogenous to local fiscal policy. BioNTech, headquartered in Mainz, Germany, experienced an unprecedented increase in profits beginning in 2021. Because corporate profits are taxed at the municipal level in Germany through the local business tax, a small number of municipalities that host BioNTech's headquarters and two production facilities received windfall revenues that exceeded their pre-pandemic annual budgets. At the same time, the size and persistence of the shock were highly uncertain, as future vaccine demand and profits were difficult to predict in real time.

Sudden and highly concentrated profit windfalls are not unique to BioNTech or similar pharmaceutical breakthroughs (such as the weigth reduction medication from Novo Nordisk), but have recently occurred across sectors, including pandemic-driven demand shocks in digital services (such as Zoom) or geopolitically induced surges in demands for weapons (such as Rheinmetall in Germany), each generating localized and difficult-to-anticipate tax-base expansions. Berset and Schelker, 2020 analyze the transitory windfall from a fiscal equalization transfer to Swiss municipalities in the canton of Zurich due to the IPO of Glencore on the London Stock Exchange. This substantial windfall amounts to a maximum of 4.70% of the annual current expenditures of the beneficiary municipalities compared to 154.78 % of annual current expenditures before the windfall of Mainz. Our work is complementary to the analysis of Jerch, Kahn, and Lin, 2023, who analyze negative shocks to local public finances from hurricanes. The exact location of a hurricane's landfall is unknown ex ante, but unlike our case, forecasts typically identify the broader regions at risk and the approximate timing of coastal impact. Truly unpredictable surprises to local tax revenues are rare and empirically difficult to isolate.

The BioNTech episode offers an opportunity to study how local governments adjust tax and expenditure policy when faced with a revenue shock that is simultaneously large, sudden, and

uncertain. Unlike formula-based intergovernmental transfers or gradual tax base changes, the shock was neither anticipated nor driven by local policy choices. In addition, its localized nature allows for a credible comparison with similar municipalities that were not affected by the breakthrough.

Using a synthetic difference-in-differences design (Arkhangelsky et al., 2021), we document three main findings. First, despite the unprecedented increase in revenues, treated municipalities did not expand discretionary current spending. Current expenditure and public investment remained largely unchanged relative to comparable control municipalities. Second, municipalities used a substantial share of the windfall to repay debt, build reserves and mechanically increase contributions to the fiscal equalization system, thereby strengthening their net asset positions. Third, municipalities temporarily reduced local business and property tax rates. These tax cuts were sizable but short-lived and were largely reversed within a few years as windfall and regular revenues declined.

We interpret these findings through the interaction of policy makers' expectations on the one hand and institutions on the other. Budget projections show that municipalities initially underestimated the size of the shock, but overestimated its persistence. Under these beliefs, temporary tax cuts were ex ante consistent with perceived permanent revenue gains. However, once revenues fell back toward pre-shock levels, a balanced-budget rule and fiscal oversight interventions constrained the ability to finance continued tax reductions or spending increases using reserves.

The BioNTech windfall also allows us to examine whether large but uncertain revenue shocks generate real economic responses at the local level. In response to the surge in business tax revenues, treated municipalities enacted substantial reductions in local business and property tax rates, albeit for a limited period. We study whether firms responded to these tax changes by adjusting entry, exit, relocation, or acquisition decisions. We find that firm responses were modest and short-lived: entry and acquisition activity increases only briefly, relocations do not respond systematically, and effects reverse as revenues decline and tax rates are restored. These patterns suggest that firms did not perceive the tax cuts as a durable change in the local economic environment, consistent with the temporary nature of the policy response and uncertainty about the persistence of the underlying revenue shock.

Our results contribute to three strands of literature. First, we extend the evidence on the fiscal response to a revenue shock that is much larger than what has been considered in previous work (Dahlberg et al., 2008; Helm and Stuhler, 2024; Berset, Huber, and Schelker, 2023). Second, we provide direct evidence on how uncertainty about persistence shapes fiscal policy choices. Third, we show that fiscal institutions such as fiscal rules and fiscal oversight bodies designed to enforce short-run budget balance (Grembi, Nannicini, and Troiano, 2016; Christofzik and Kessing, 2018) can limit intertemporal smoothing even when governments experience extraordinary revenue windfalls.

Our paper is closely related to Poterba (1994), which studies how balanced-budget rules and political institutions shape state responses to unexpected fiscal deficits. We extend this framework

in three ways. First, previous work including Poterba (1994) emphasizes that fiscal responses may depend on whether shocks are transitory or permanent; we directly observe revenue expectations and forecast revisions, providing evidence on learning about shock persistence. Second, while borrowing constraints may mechanically affect fiscal responses, we show that institutional constraints limit intertemporal smoothing even when governments accumulate exceptionally large reserves, thereby isolating the role of flow-based fiscal rules from liquidity constraints. Third, we add evidence on large and unexpected positive revenue shocks, allowing us to analyze asymmetric responses to positive and negative tax shocks.

Prior studies identify tax shocks using narrative or time-series approaches and focus on nationally legislated reforms, where identification relies on institutional timing and exogeneity assumptions C. D. Romer and D. H. Romer (e.g., 2010), Mertens and Ravn (2012), and Christofzik, Fuest, and Jessen (2022). We complement this literature by exploiting a large, localized revenue windfall and cross-municipal variation in exposure within a common institutional framework, which allows for a transparent quasi-experimental design and direct estimation of local responses to tax changes.

By exploiting cross-municipal variation in exposure to a common national shock, our design isolates local tax responses within a shared macroeconomic and institutional environment. This reduces confounding from aggregate policy changes and anticipation effects, strengthening the credibility of the estimated local effects.

Our paper relates to work on local fiscal and demand shocks, such as Auerbach, Gorodnichenko, and Murphy (2020), who document large and persistent local real effects of defense spending shocks that are credibly long-lived. In contrast, we show that even exceptionally large revenue windfalls generate only modest and transitory firm responses when they operate through temporary tax policy under institutional and fiscal constraints.

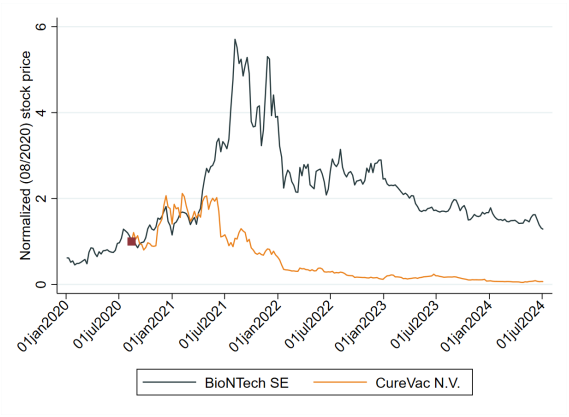
Compared to Berset and Schelker (2020) who find an overreaction to a broadly shared windfall, even if it was known to be transitory, our analysis highlights how uncertainty about persistence interacting with flow-based balanced-budget oversight can instead produce caution on spending, balance-sheet adjustment, and tax cuts.

Taken together, our findings suggest that large and unexpected revenue surges do not automatically translate into higher public spending or sustained tax relief. Instead, fiscal responses are shaped by uncertainty, expectations, and institutional constraints that govern how governments adjust to both positive and negative shocks.

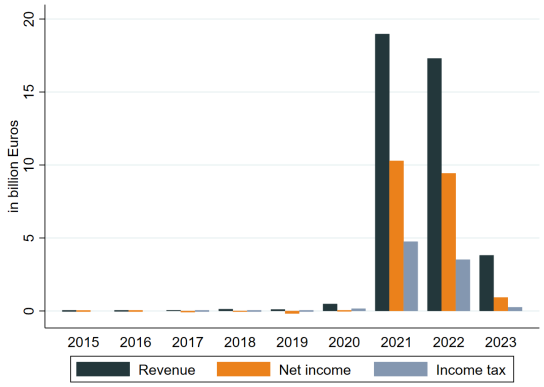
2 The BioNTech Budget Windfall Shock

The BioNTech breakthrough generated an unusually large localized revenue shock in Germany. Figure 1 illustrates both the timing and the magnitude of the shock. Although BioNTech had

operated for years with modest revenues and limited profitability, its successful development of an mRNA-based COVID-19 vaccine led to a sudden and dramatic increase in global demand, revenues, and profits beginning in late 2020 Figure 1b).

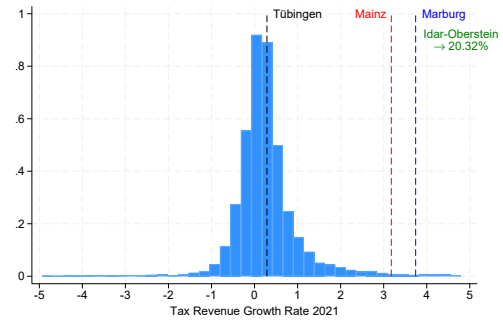


(a) Weekly Normalized Closing Stock Prices



(b) BioNTech Key Financial Figures

(c) Tax Revenue Growth Rates 2018–2022



(d) Tax Revenue Growth Rates in 2021

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

Note: Figure (a) shows the weekly normalized closing stock prices of BioNTech (since January 2, 2020), headquartered in Mainz with establishments in Idar-Oberstein and Marburg, and Curevac (since August 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 vaccines by May 6, 2021. On June 16, 2021, Curevac announced a vaccine efficacy of only 47%. Figure (b) shows the increase in BioNTech's net income from €15.2 million in 2020 to €10.3 billion in 2021 and €9.4 billion in 2022. Figure (c) shows tax revenue per capita in BioNTech municipalities Mainz and Idar-Oberstein. Figure (d) compares the BioNTech tax revenue shock to the distribution of tax revenue growth rates across approximately 11,000 German municipalities in 2021, ranging from −500% to 500%.

Because German municipalities levy a local business tax on corporate profits ("Gewerbesteuer"), this surge translated almost mechanically into municipal revenues (Figure 1c). In practice, these revenues are highly concentrated in the municipalities where the relevant tax base is recorded under the local business tax system, rather than being apportioned to final consumer locations. As a result, fiscal gains were concentrated in a small number of municipalities hosting BioNTech's headquarters

in Mainz and two production facilities in Idar-Oberstein and Marburg.

Panel (a) of Figure 1 shows the rapid divergence of stock prices of BioNTech and its closest domestic competitor Curevac, following the announcement of vaccine efficacy results in early 2021. The increase in profits was not gradual, but occurred over a short period of time, compressing years of potential revenue growth into a single fiscal year. This timing limits concerns that the shock reflects local economic trends or anticipatory behavior by municipalities.

Panels (c) and (d) place the resulting municipal revenue increases in a broader context. The treated municipalities experienced business tax revenue growth rates that lie far in the right tail of the distribution across German municipalities. In Mainz, additional revenues exceeded pre-pandemic annual budgets by a wide margin. Even in relation to other biotech hubs, the magnitude of the shock was exceptional.

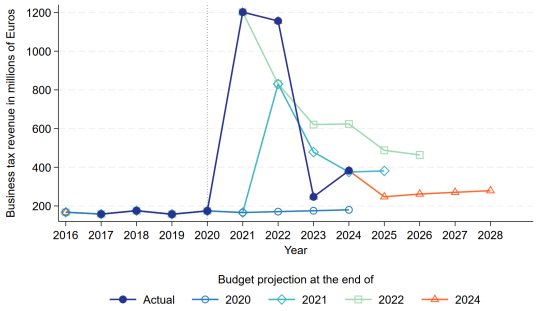
Two features distinguish this episode from most revenue changes studied in the literature. First, the shock was plausibly exogenous to local fiscal policy: municipalities did not influence BioNTech's success, nor could they meaningfully adjust tax policy before the shock materialized. Second, the shock was extreme in size relative to the variation typically used to study local public finance responses (e.g., Dahlberg et al., 2008; Helm and Stuhler, 2024; Berset, Huber, and Schelker, 2023).

These features make the episode particularly informative for studying fiscal behavior under uncertainty. Large positive shocks relax short-term budget constraints but also raise questions about how governments allocate resources over time. The sheer size of the windfall implies that standard incremental adjustments—such as marginal spending increases—may be neither feasible nor desirable. Instead, municipalities must make large adjustments in spending, reserve build-up, debt reduction, or tax policy.

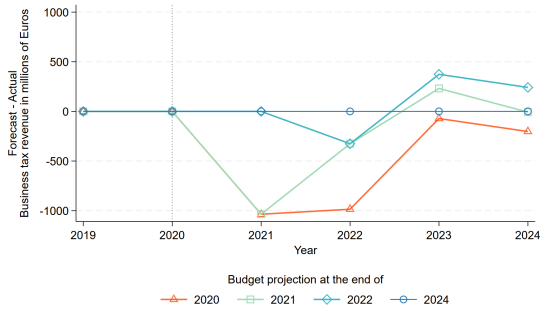
At the same time, the localized nature of the shock allows us to construct credible counterfactuals. Other municipalities within the same federal state provide a natural comparison group that share institutional rules, macroeconomic conditions, and pandemic-related disruptions, but did not benefit directly from the BioNTech breakthrough. This setting underpins our empirical strategy and allows us to trace dynamic fiscal responses over several years.

3 Uncertainty about the Persistence and Size of the Shock

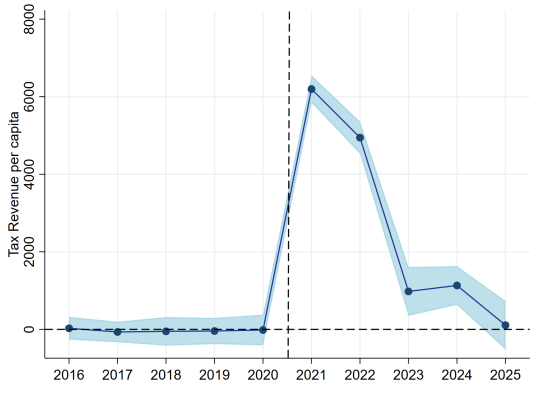
While the magnitude of the BioNTech windfall is evident ex post, its persistence was highly uncertain. Unlike revenue changes generated by formula-based intergovernmental transfers or gradual tax base growth, the BioNTech shock combined an abrupt increase in revenues with substantial ambiguity about how long elevated profits would last. Municipalities therefore had to form expectations about both the size and duration of the shock while committing to budget plans and tax policy in real time.



(a) Budget Projections



(b) Forecast Error



(c) Tax Revenues in Euros per capita

Figure 2: Budget Projections and Evolution of Local Business Tax Revenues in Mainz

Note: The figure shows Mainz's projected and realized business tax revenues based on municipal budget plans prepared at different points in time. Projections are revised at the end of 2020, 2021, 2022, and 2024. Instead of adopting a budget for only one year, municipalities may pass a two-year budget (Doppelhaushalt). Therefore, a revision from 2023 is not available. Projections from late 2021 anticipated a sharp revenue increase in 2022 followed by persistently higher revenues relative to pre-2021 levels. Updated forecasts in 2022 incorporated the realized revenue surge in 2021 and the expected effects of a reduction in the local business tax rate. Subsequent projections in 2023 and 2024 reflect a faster-than-expected decline in revenues, indicating that the tax revenue shock was larger but more temporary than initially anticipated. 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.

Figure 2 documents how expectations and realizations evolved. Panel (a) shows business tax revenue projections from successive municipal budget plans in Mainz. Projections prepared in late 2021 anticipated a sharp increase in revenues in 2022 followed by persistently higher levels relative to the pre-pandemic period. Budget plans prepared in 2022 incorporated the unexpectedly large realization in 2021 but continued to extrapolate elevated revenues several years into the future. Only in later projections, prepared in 2023 and 2024, did municipalities substantially revise expected revenues downward.

Panel (b) quantifies this adjustment process using forecast errors. Forecast errors (forecast - actual) are large and systematically negative in the early post-shock period, indicating that municipalities initially underestimated realized revenues. For instance, tax revenues for 2021 were projected in 2020 to remain roughly constant, but the gap between projected and actual revenues amounted to 149.16% of average annual total revenues and 154.78% of average annual expenditures over 2016–2020. Even after the first revenue surge, projections continued to fall short of outcomes. As revenues decreased, forecast errors turned positive, reflecting delayed downward revisions in expectations. Even in late 2022, tax revenues for 2022 were underestimated by 46.9% of average annual tax revenues and 48.67% of average annual expenditures during 2016–2020, but those for 2023 were overestimated by 53.80% and 55.83%. The pattern points to gradual learning rather than immediate recognition of the transitory nature of the shock.

Panel (c) places these expectations in the context of realized revenue dynamics. To do this, we construct synthetic difference-in-differences a counterfactual by optimally weighting untreated municipalities and pre-treatment periods so that the weighted control group closely matches treated municipalities prior to the shock (Arkhangelsky et al., 2021). The average treatment effect on the treated (ATT) is computed as

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

The intercept is denoted by μ, while α_i and ξ_t denote municipality and year fixed effects, respectively. The binary treatment indicator D_{it} is equal to one for the treatment municipalities starting in 2021 and zero otherwise. Synthetic difference-in-differences yields an average treatment effect on the treated (ATT) that is simply the average of $\hat{\beta}^{sdid}$ in the post-treatment period, which are the coefficients of interest. The synthetic control draws on a broad set of municipalities from the state of Rhineland-Palatinate (the state of BioNTech's headquarter in Mainz and its production facility in Idar-Oberstein), with no single unit receiving more than 12% weight (see Table B.3). The synthetic difference-in-differences estimates have been transformed into event study graphs (Ciccia, 2024). Relative to a weighted synthetic control group with similar pre-treatment trends, treated municipalities experienced a discrete and pronounced increase in business tax revenues starting in 2021. Revenues compared to the synthetic municipalities peaked in 2022 at around €6,000 per capita—far exceeding historical variation—before declining sharply in 2023 and converging back toward control-group levels. The implied average treatment effect is approximately €3,440 per capita. The timing of the peak and subsequent decline aligns closely with the forecast revisions in panels (a) and (b), indicating that fiscal decisions were made while the true persistence of the shock was still unfolding.

Two patterns emerge. First, municipalities initially underestimated the size of the shock. Early budget plans did not anticipate the full magnitude of BioNTech's profits or the resulting tax revenues.

Second, and more importantly, they overestimated its persistence. The expectation that revenues would remain high shaped fiscal decisions taken in the immediate aftermath of the shock.

The combination of uncertainty and gradual learning creates a different decision environment from one in which the duration of a revenue change is known. In standard intertemporal frameworks, governments smooth spending in response to transitory shocks and adjust taxes primarily in response to permanent changes (cf. Barro, 1979). When policymakers misperceive a transitory shock as permanent, temporary tax cuts or delayed spending adjustments can be ex ante consistent with perceived permanent-income gains, even if they later prove unsustainable.

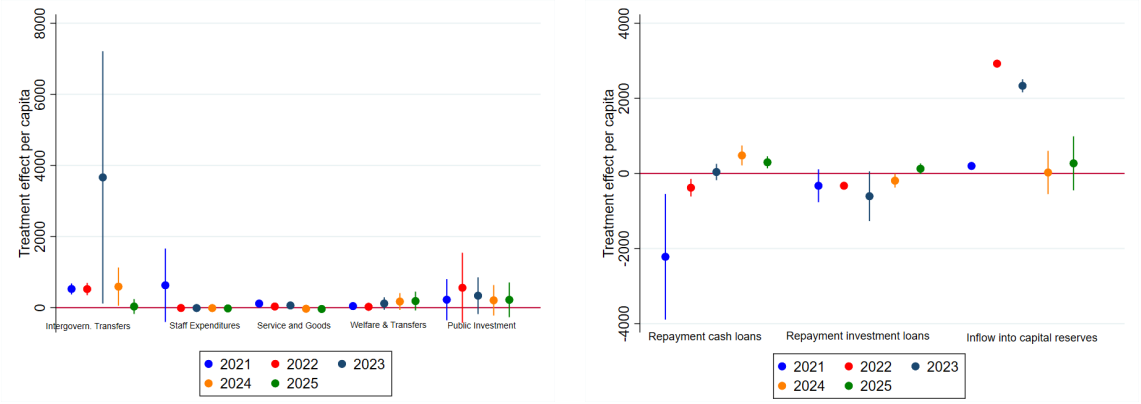
The BioNTech episode thus forces us to interpret fiscal policy under uncertainty rather than under full information. Faced with a large but ex-ante poorly understood revenue shock, municipalities were reluctant to make hard to reverse commitments, such as increasing staff in the public sector which has strong labor rights, while relying on more easily reversible policy instruments.

In the sections that follow, we show that this uncertainty is reflected in observed fiscal behavior. Municipalities responded cautiously on the spending side, avoiding irreversible commitments while simultaneously implementing temporary tax cuts that were consistent with beliefs about persistent revenue gains. As expectations adjusted, fiscal rules and oversight mechanisms constrained municipalities' ability to smooth these adjustments over time (see also Christofzik, 2019).

4 Budgetary Responses

How did municipalities allocate the BioNTech windfall across spending, saving, and balance sheet adjustments? Figure 3 summarizes the dynamic response across major budget categories following treatment. We run Equation (1) on all available expenditure and balance sheet categories described in Table A separately.

Panel (a) shows that current spending remained remarkably stable. We find no economically meaningful increase in staff expenditures, service provision, or welfare payments relative to control municipalities. Public investment also did not respond systematically, despite the availability of unprecedented fiscal resources. These findings contrast with classic flypaper patterns in which marginal revenues often translate into higher local spending (see Hines and Thaler, 1995 and related evidence in Dahlberg et al., 2008) but are consistent with earlier findings that strong budgetary institutions, such as balanced budget rules, can constrain spending even in the face of large surpluses (Poterba, 1994).



(a) Current Spending

(b) Debt and Reserves

Figure 3: Budgetary Response: Annual Treatment Effects

Note: The figure shows annual treatment effects on major budget categories following treatment. Panel (a) reports responses in current spending, while panel (b) reports responses in debt and reserves. Estimates are expressed as per capita estimates of the respective annual treatment effect in each post-treatment year.

The absence of a current spending response is particularly striking given the size of the shock. In Mainz, additional revenues exceeded pre-pandemic annual expenditures by a wide margin. Even if municipalities had anticipated that the shock was temporary, its magnitude would have allowed for a gradual expansion of spending spread over several years without jeopardizing fiscal sustainability. That this did not occur points to strong constraints on local fiscal policy.

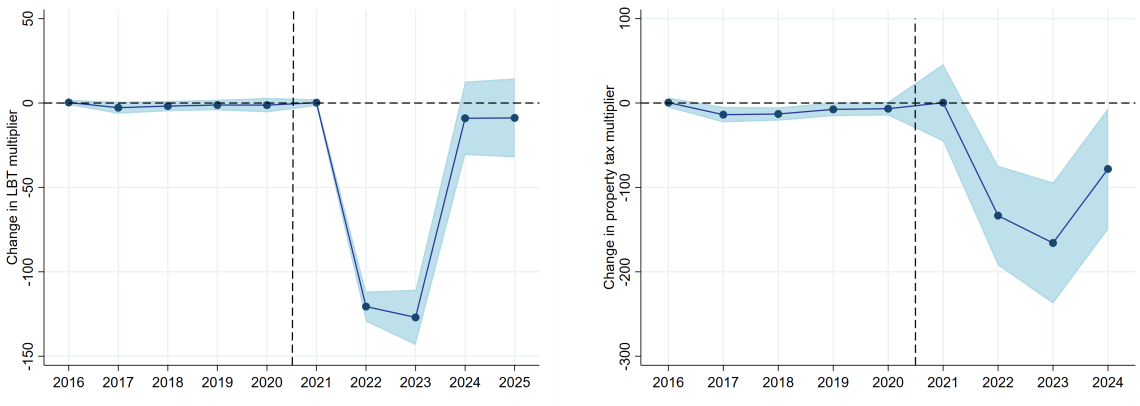
Panel (b) shows where the money went instead. Treated municipalities used a large share of the windfall to repay outstanding debt and accumulate reserves, substantially improving their net asset positions. These balance sheet adjustments occurred quickly and persisted over time. In addition, higher revenues mechanically increased contributions to the fiscal equalization system, redistributing part of the shock to other municipalities. We return to this issue, as one might worry that this could affect our control group municipalities.

The response pattern is consistent with the interaction between uncertainty and fiscal rules. On the one hand, municipalities avoided irreversible spending commitments in an environment where the persistence of revenues was unclear. Expanding personnel or launching new investment projects would have raised future spending obligations that might prove difficult to unwind if revenues declined. On the other hand, debt repayment and reserve accumulation provided a low-risk way to absorb temporary revenues without locking in future commitments or liabilities.

Taken together, the evidence suggests that municipalities treated the BioNTech windfall primarily as a balance sheet event rather than as an opportunity to expand public service provision. This cautious approach set the stage for the tax policy adjustments discussed next.

5 Local Tax Policy and Firm Responses

While municipalities refrained from increasing spending, they actively adjusted local tax policy in response to the revenue shock. The local business tax rate is a tax on profits and varies by municipality. Municipalities set a minimum tax multiplier of 200%. The tax on businesses results by multiplying this with 3.5%. For example, in 2021 the local business tax rate in Mainz was $440 \times 3.5\% = 15.4\%$. The property tax works similarly but is multiplied with different factors depending on the type of property. Revenue from the local business tax is the most important source of revenue for municipalities. Figure 4 documents changes in the local business tax and property tax multipliers following treatment.



(a) Local Business Tax Multiplier

(b) Property Tax Multiplier

Figure 4: Tax Policy

Note: The figure shows changes in (a) the local business tax multiplier and (b) the property tax multiplier. Estimates compare treated municipalities to a synthetic control group using a synthetic difference-in-differences (SDID) approach. Both tax multipliers decline following the BioNTech shock and revert toward pre-shock levels after approximately three years.

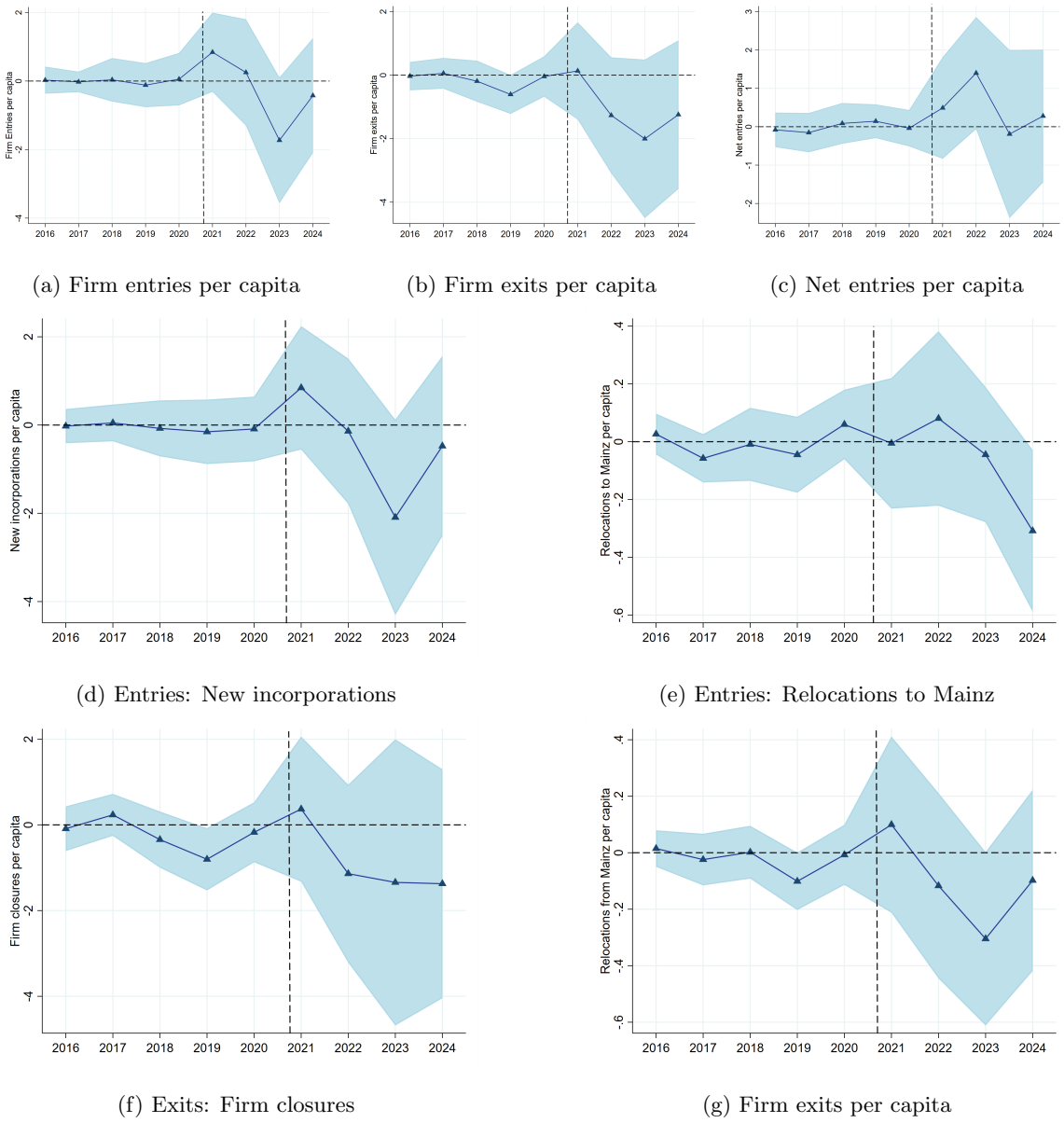
Panel (a) shows a sharp decline in the local business tax multiplier in 2022. In Mainz, the multiplier fell by more than 130 percentage points from a pre-shock level of 440%, implying a tax rate cut from $440 \times 3.5\% = 15.4\%$ to 10.85%. Such changes are unusual in settings where local tax rates are typically persistent and adjust only intermittently (see evidence on local tax interactions in Parchet, 2019; Allers and Elhorst, 2005). Panel (b) shows a smaller but statistically significant reduction in property tax multipliers.

These tax cuts occurred shortly after the revenue surge and were reversed within approximately three years as revenues declined. The timing of these adjustments closely mirrors the evolution of revenue expectations documented in Section 3. Early tax cuts coincided with optimistic beliefs about the persistence of the BioNTech shock, while reversals followed as it became clear that revenues were normalizing.

At first glance, the coexistence of conservative spending behavior and aggressive tax cuts may appear puzzling. However, this pattern is consistent with policy under uncertainty: if policymakers believed the revenue increase reflected a permanent upward shift, lowering tax rates would have been a natural response, while expanding spending would have required greater confidence about future revenues (cf. Barro, 1979).

The subsequent reversal of tax cuts highlights the limits of this strategy. Once revenues declined, balanced-budget rules and fiscal oversight forced municipalities to adjust quickly, as the balanced budget rule in the state of Rhineland-Palatinate requires a balanced budget in terms of cash accounting as well as accrual accounting. Because spending had not increased compared to the control group, the primary margin of adjustment was tax policy. As a result, municipalities were compelled to raise tax rates again despite holding substantial reserves.

The temporary nature of tax cuts also has implications for local economic effects. Although lower business tax rates may have stimulated activity in the short run, their rapid reversal likely limited the scope of longer-term behavioral responses. From the perspective of firms, the episode may have appeared as a brief and uncertain deviation from the status quo rather than a durable change in the local tax environment (see, e.g., Janeba and Osterloh, 2013; Parchet, 2019). This is reflected in firm responses to these tax cuts, which we show below.



(a) Firm entries per capita

(b) Firm exits per capita

(c) Net entries per capita

(d) Entries: New incorporations

(e) Entries: Relocations to Mainz

(f) Exits: Firm closures

(g) Firm exits per capita

Figure 5: Firm effects

Note: The figure shows changes in (a) the entries (b) the exits and (c) the net effect, that is (a) minus (b), in Mainz relative to all other German county-free cities. Estimates compare firm dynamics in Mainz to a synthetic control group using a synthetic difference-in-differences (SDID) approach.

Overall, the evidence shows that local tax policy was the primary active adjustment margin following the BioNTech shock. Spending remained stable, balance sheets improved, and tax rates moved sharply but temporarily in response to evolving expectations and binding fiscal rules.

Table 1: Treatment Effects for Accepted and Rejected Budget Proposals

Outcome	ATT_{rej}	SE_{rej}	ATT_{acc}	SE_{acc}	ΔATT	p-value
Panel A: Expenditures						
Total Expenditure	1023.00	321.44	1030.00	321.44	7.00	0.988
Staff Expenditure	247.22	70.26	251.51	70.26	4.29	0.966
Service Expenditure	17.77	58.95	18.16	58.95	0.39	0.996
Transfers	294.04	160.59	294.47	160.60	0.43	0.999
Welfare	203.18	100.82	215.98	100.82	12.81	0.928
Public Investment	560.02	602.28	549.97	602.28	-10.05	0.991
Panel B: Fiscal Adjustments						
Reserves (Inflow)	930.86	345.39	899.13	345.39	-31.73	0.949
Business Tax Multiplier	-112.00	8.86	-55.87	8.87	56.13	0.000

Note: Notes: ATT_{rej} and ATT_{acc} denote average treatment effects for rejected and accepted budget proposals. ΔATT is the difference between accepted and rejected proposals. p-values are from two-sided Wald tests.

6 The Limits to Local Expenditure and Tax Policy

Why were municipalities unable to sustain tax cuts or expand spending despite accumulating historically large reserves? Table 1 focuses on Mainz and compares treatment effects relative to a synthetic Mainz for two versions of the city's two-year budget plan for 2023/24: a rejected proposal with its reduced business tax multiplier and a revised, accepted proposal complying with fiscal oversight. Fiscal oversight enforces the rule to accept proposals only if current budget flows are balanced. The idea of the comparison of treatment effects is that all other parameters such as expectations about the evolution of tax revenues were the same in both budget processes and so any difference in policy behavior is simply due to the bite of the fiscal rule.

In the case of Mainz, this fiscal rule became binding for the two-year budget plan 2023/2024. As the BioNTech windfall proved to be largely transitory, the city recorded a renewed deficit of approximately €200 million in 2024.

For nearly all expenditure categories, treatment effects are statistically indistinguishable between the accepted and rejected budgets. This includes total expenditure, personnel spending, transfers, and public investment. In contrast, the treatment effect on the local business tax multiplier differs sharply across the two groups. Municipalities whose budgets were accepted reduced business tax rates substantially less than those whose proposals were rejected, and the difference is both economically large and statistically significant.

This pattern highlights an institutional asymmetry: fiscal oversight constrains the feasibility of sustaining revenue instruments (notably tax cuts) once revenues decline, even when balance sheets

have improved (see related institutional discussion in Christofzik, 2019; Poterba, 1994). While municipalities retain discretion over how to allocate spending within a balanced budget, they face strict limits on running deficits or maintaining tax cuts when current revenues fall short of expenditures.

From an economic perspective, this constraint limits intertemporal smoothing. In principle, municipalities could use accumulated reserves to finance temporary revenue shortfalls and maintain lower tax rates or higher spending levels. In practice, fiscal rules and oversight emphasize contemporaneous budget balance, which can force rapid policy reversals even when governments are wealthy in net terms.

7 Conclusion

This paper studies how local governments respond to an extreme and unexpected revenue windfall. Exploiting quasi-experimental variation generated by BioNTech's COVID-19 vaccine breakthrough, we analyze the fiscal responses of German municipalities that experienced unprecedented increases in business tax revenues.

We find a strikingly cautious response. Municipalities did not expand discretionary spending despite revenues that dwarfed historical variation. Instead, they prioritized debt repayment, reserve accumulation, and fiscal equalization transfers. At the same time, they temporarily reduced local tax rates, reflecting optimistic expectations about the shock's persistence. Once revenues declined, fiscal oversight and balanced-budget requirements forced municipalities to reverse most of these tax cuts, even though their balance sheets remained strong.

These findings underscore three broader lessons. First, fiscal responses to very large revenue shocks can differ from responses to smaller or more predictable changes studied in prior work (e.g., Dahlberg et al., 2008; Helm and Stuhler, 2024). Second, expectations about the permanence of revenue changes play a central role in shaping policy choices under uncertainty (cf. Barro, 1979). Third, institutional design matters: fiscal rules that focus on cash flows rather than net wealth can limit governments' ability to smooth policy over time (see also Christofzik, 2019).

Taken together, our results suggest that large windfall revenues do not automatically translate into higher public spending or sustained tax reductions. Instead, uncertainty and institutional constraints shape how governments absorb and unwind even extraordinary fiscal shocks.

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Supplementary Appendix

A Budget Item Description

Table A.1: Municipal Balance Sheet Data

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

Table B.1: Descriptive Statistics: Before Treatment (Averages 2016-2020)

	Treatment Group		Control Group		Mean Difference	
	Mean	SD	Mean	SD	Difference	t-statistic
Revenues per capita (€)						
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)
Intergovernmental Grant 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)
Current Spending per capita (€)						
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)
Intergovernmental Grant 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)
Balance sheet per capita (€)						
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 B.2: Descriptive Statistics: After Treatment (Averages 2021-2025)

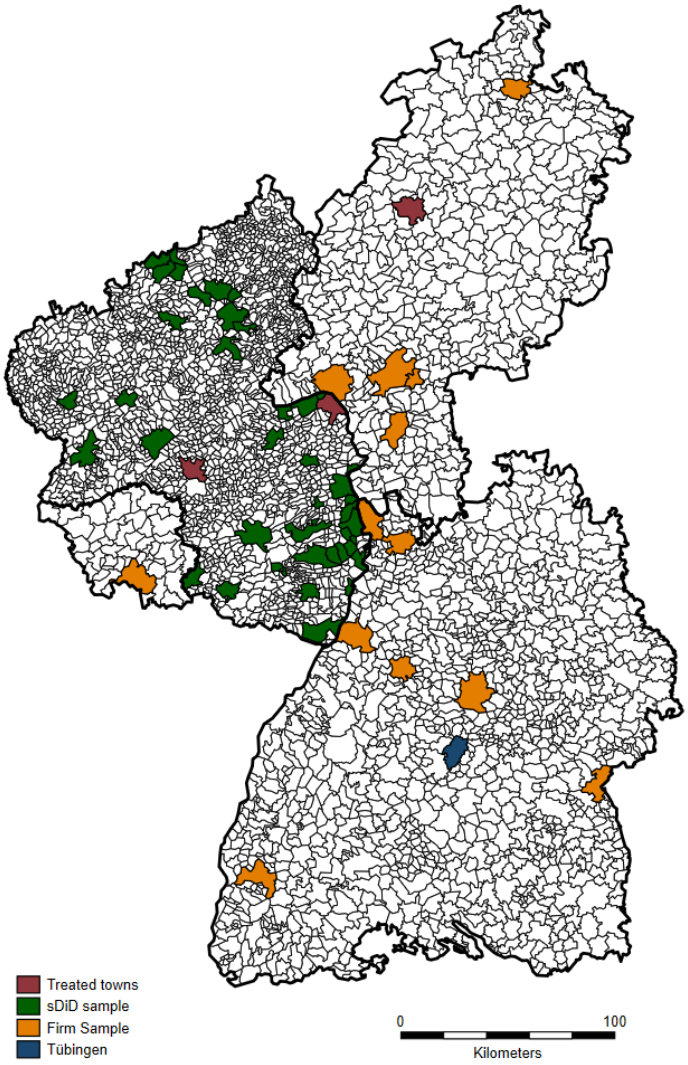
	Treatment Group		Control Group		Mean Difference	
	Mean	SD	Mean	SD	Difference	t-statistic
Revenues per capita (€)						
Total Revenue	7562.99	2492.05	3480.97	1228.65	-4082.02**	(-4.58)
Tax Revenue	5136.96	2435.56	1930.18	1165.46	-3206.78**	(-3.69)
Intergovernmental Grant Revenue	506.15	213.34	720.68	382.80	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)
Current Spending per capita (€)						
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)
Intergovernmental Grant 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)
Balance sheet per capita (€)						
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	

Table B.3: Distribution of SDID Unit Weights by Municipality

Municipality	Population	Mean Weight	Min. Weight	Max. Weight
Koblenz	115,298	0.03450	0.00000	0.07780
Remagen	17,387	0.02733	0.01399	0.04087
Sinzig	17,399	0.02746	0.00277	0.05953
Grafschaft	10,866	0.01726	0.00000	0.03356
Bad Kreuznach	52,989	0.02884	0.00000	0.04948
Andernach	30,408	0.02583	0.01725	0.03533
Mayen	19,882	0.03359	0.00865	0.08187
Bendorf	17,208	0.03235	0.01496	0.07590
Neuwied	66,243	0.02938	0.00000	0.05150
Boppard	15,593	0.04801	0.02629	0.15021
Lahnstein	18,536	0.03182	0.00000	0.09511
Trier	112,461	0.03932	0.00000	0.10088
Wittlich	19,718	0.02677	0.01192	0.03349
Morbach	10,687	0.02586	0.00000	0.04325
Bitburg	17,465	0.02949	0.01075	0.04714
Frankenthal	49,122	0.02369	0.00000	0.03112
Kaiserslautern	101,486	0.02972	0.00000	0.05844
Landau (Pfalz)	48,341	0.03267	0.00015	0.08901
Ludwigshafen	176,110	0.03208	0.00000	0.06472
Neustadt (Weinstraße)	53,920	0.02643	0.01065	0.03671
Pirmasens	40,941	0.03817	0.01839	0.07875
Speyer	50,565	0.02591	0.00000	0.07196
Worms	85,609	0.02881	0.01693	0.04299
Alzey	20,289	0.03440	0.00000	0.08311
Bad Dürkheim	18,821	0.03270	0.00651	0.05377
Grünstadt	14,169	0.02615	0.00285	0.04063
Haßloch	20,450	0.02390	0.00433	0.03350
Germersheim	21,295	0.03103	0.01696	0.05637
Wörth am Rhein	18,405	0.02309	0.00562	0.04320
Bobenheim-Roxheim	10,157	0.02905	0.00000	0.04455
Böhl-Iggelheim	10,586	0.03085	0.00000	0.05362
Limburgerhof	11,781	0.01964	0.00000	0.03395
Schifferstadt	20,682	0.02351	0.00000	0.03694
Bingen am Rhein	26,339	0.02445	0.00995	0.04958
Ingelheim am Rhein	36,390	0.01215	0.00000	0.03335

Note: This table lists all municipalities in the donor pool in the synthetic control group design and their population in 2025 as well as the average, minimum and maximum estimated unit weight across all estimations.

Figure B.1: Map of Samples



Note: The Figure depicts municipalities used in the respective estimation samples. Going from north to south, treated municipalities are Marburg, Mainz and Idar-Oberstein. Green-shaded municipalities are the donor pool for the baseline synthetic control group. Thick black lines indicate state borders. Going from north to south, the states are Hesse, Rhineland-Palatinate, Saarland and Baden-Württemberg. Orange municipalities are part of the firm sample that used for the firm response analysis. Tübingen is indicated in blue.

C Exogeneity Check

We conduct an exogeneity check in Figure C.1. We regress pre-treatment changes (2016–2020) in economic covariates, budget items, and local tax multipliers on the treatment variable within the synthetic difference-in-differences sample, without constructing the synthetic control group. The results show no statistically significant differences in trends between BioNTech municipalities and the unaltered control sample, reinforcing the notion that the BioNTech shock was exogenous to local policymakers and not driven by prior fiscal policy decisions.

Figure C.1: BioNTech Shock and pre-treatment trends

Note: The Figure represents bivariate regression estimates: We regress the pre-treatment changes (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.

D Local Public Finance in Germany

The federal and state governments experienced significant tax revenue increases due to BioNTech's higher corporate income tax payments, amounting to €4.8 billion in 2021 and €3.5 billion in 2022. The local business tax directs approximately half of revenues from overall taxable profit to the municipalities where the firm's production sites are located. As a result, all three of BioNTech's sites have seen strong increases in local tax revenues, while other municipalities have benefited only indirectly, if at all. For municipalities, the local business tax is typically the most important revenue source. In total, it generated around €70 billion in Germany in 2022, accounting for approximately 50% of total municipal tax revenue. BioNTech's tax boom had ramifications for the federal and state budgets (the state of Rhineland-Palatinate, in which Mainz and Idar-Oberstein are located, briefly became a donor in the equalization scheme among states). Figure D.1 illustrates the system of corporate profit taxation in Germany and highlights with red arrows the channels of interest in this study. In the main text we focus on the direct effect of local business tax revenues on municipal budgets, tax policy, and firm responses. In Appendix E we study the indirect effects of the BioNTech revenue shock through municipal fiscal equalization.

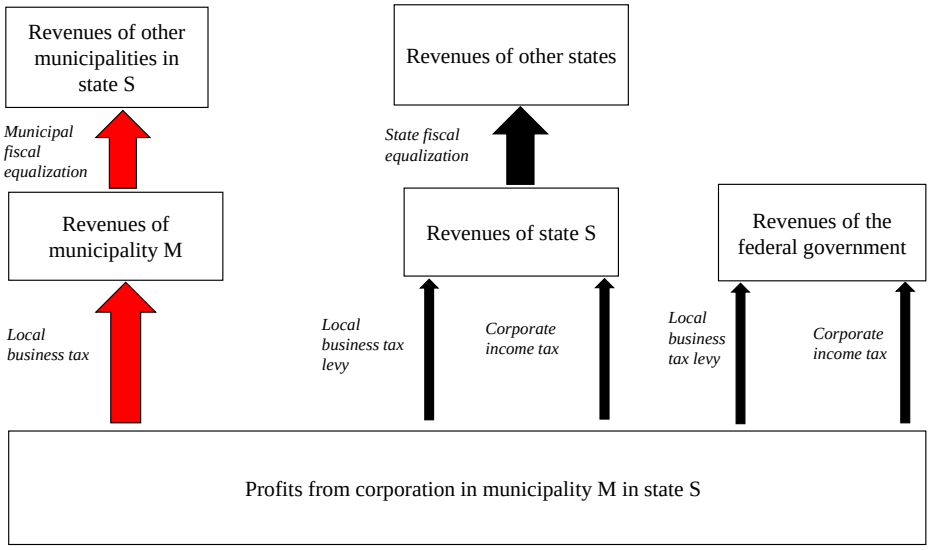


Figure D.1: Corporate profit taxation in Germany

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 intergovernmental transfers from the municipal fiscal equalization scheme (Federal Statistical Office, 2023).[1]

[1]While these systems are designed by each state individually, its mechanics are widely similar: On an annual basis, the state governments define 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 municipalities 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.

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.

E Indirect effects: Fiscal equalization effects

Municipalities with consistently high tax revenues are net contributors within municipal fiscal equalization schemes in Germany. Every state runs its own system, but the mechanics are similar in every state: For each municipalities, the states compute fiscal strength and fiscal need. The former is a function of local tax revenues and is particularly high when a city has high business tax revenues. Fiscal need increases in population size with some special provisions if the city for instance hosts NATO troops or has high welfare burdens. If fiscal strength exceeds fiscal need, a city becomes "abundant" and thus a net donor into the equalization scheme. Otherwise, the city is a recipient and receives transfers from the sceme. That is, a certain fraction of tax revenues is absorbed through the system and redistributed across all other recipient municipalities. If a city switches from be due to a large increase in local tax revenues (as in the case of Mainz and Idar-Oberstein), the payment into the equalization schemes happens with a two-year lag. As the results in Figure **??** show, this clearly happend in 2023 when the large tax revenue increases from 2021 became relevant.

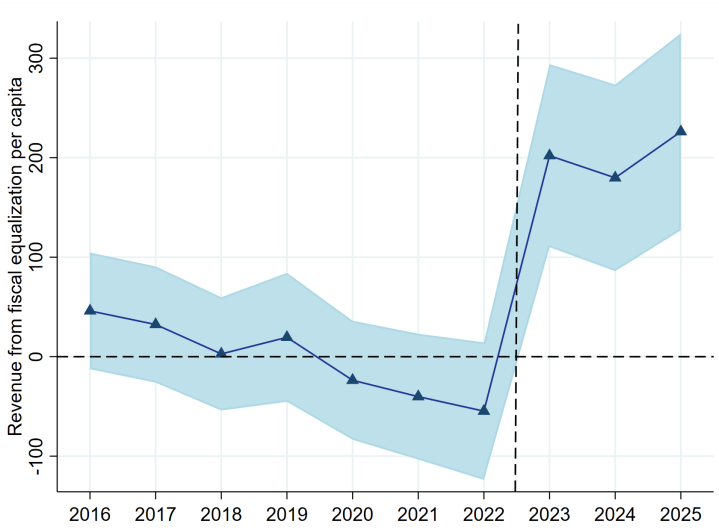


Figure E.1: Fiscal equalization effect

In our setting, this constitutes a second round revenue windfall to municipalities in Rhineland-Palatinate which stem from the initial BioNTech shock. Due to the two-year lag in the calculation of transfers, the first treatment year is 2023. This windfall becomes revelantTo fulfill the analysis of the BioNTech shock on Rhineland-Palatinate's municipalities, we estimate the fiscal response along the same budget items as for the BioNTech cities in our sample using a synthetic difference-in-difference approach with bootstrapped standard-errors[2]. We exclude Mainz and Idar-Oberstein and compare the five "abundant" municipalities with the 31 cities which receive transfers out of the fiscal equalization scheme in 2023. In figure E.1, we estimate the revenue effect on the recipient municipalities.

While imprecisely estimated, there is a strong increase in revenues from transfers out of the fiscal equalization system. The effect averages around €200 per year which amounts to roughly €1 billion in additional revenues from the fiscal equalization scheme across three years.

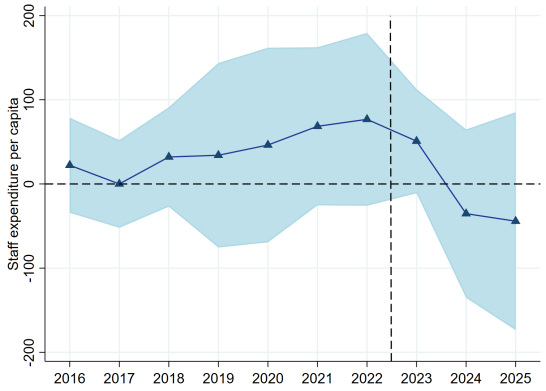
In figure E.2, we study the effect on current spending categories and public investment. We detect no statistically significant upticks in spending and a insignificant reduction in staff expenditure in municipalities who benefit from additional funds within the equalization scheme.

As for the BioNTech-headquarter cities, we extend the analysis to cash and investment loan repayments and inflow into capital reserves. Figure E.3 shows that, while not significant at the 5

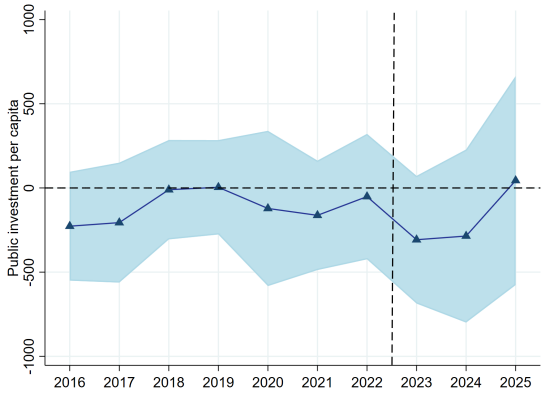
[2]Since synthetic DiD uses a combination pre-treatment post weights to calculate the treatment effect, we cannot compare the effect to a single pre-treatment year. The treatment effect is always relative to the composition of pre-treatment time weights.

Figure E.2: Fiscal equalization effects: Current spending

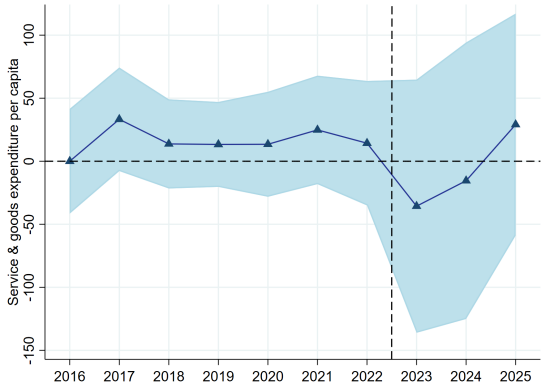
(a) Staff Expenditure



(b) Public Investment



(c) Service & Goods Expenditure



(d) Welfare Spending

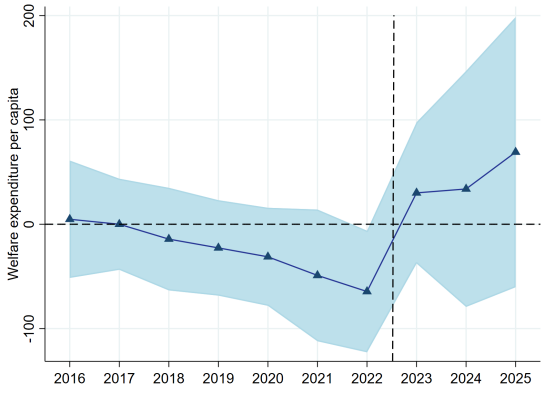
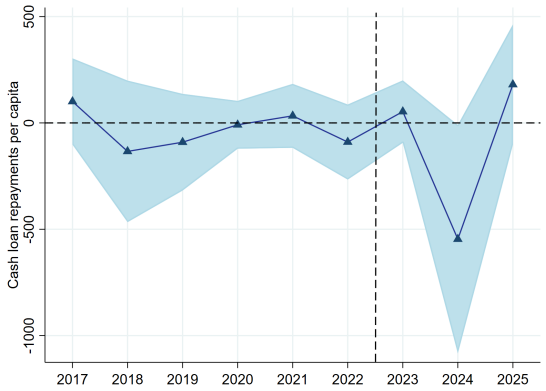
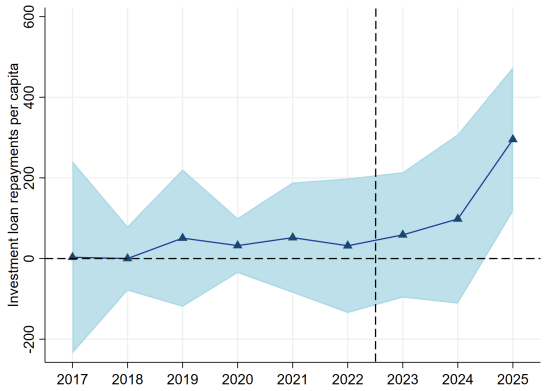


Figure E.3: Fiscal equalization effects: Debt & Reserves

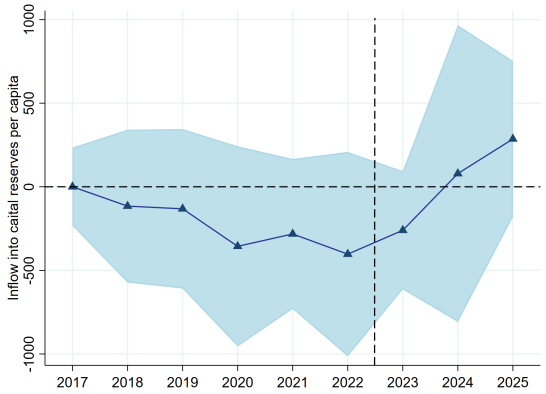
(a) Cash loan repayments



(b) Investment loan repayments



(c) Inflow into capital reserves



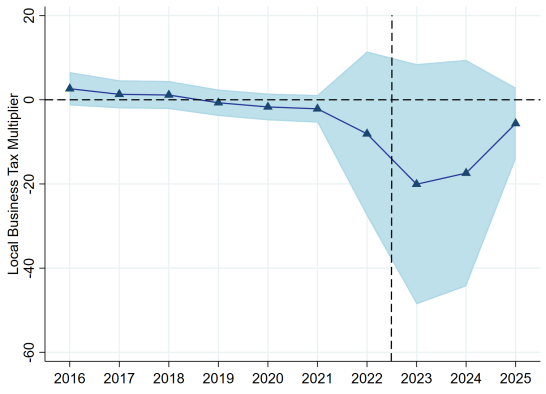
% level, municipalities repay cash loans in the year following the fiscal equalization revenue shock. With a treatment effect of around €500 per capita in 2024, this amounts to a reduction of cash loan liabilities €907 million. Hence, the majority of additional revenues is spent on reducing outstanding debt. Interestingly, the treated municipalities issue more investment loans than the abundant municipalities. However, we interpret this as them having a worse fiscal situation overall and requiring additional funds to maintain public investment.

We also analyze tax rate responses to the fiscal equalization revenue gains (E.4). As for the property tax rate, we have to restrict our analysis to 2023 and 2024 as the nationwide property tax reform makes tax rates no longer comparable across time. Relative to abundant municipalities, treated municipalities seem to cut back on the local business tax rate and increase the property tax rate. However, both effects are imprecisely estimated suggesting lot of variation in tax rate responses.

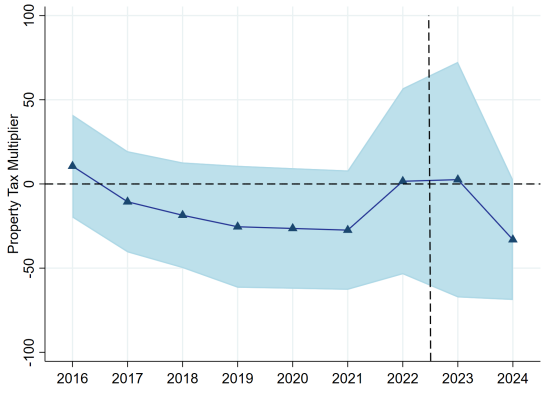
While the additional revenue from the fiscal equalization scheme is much lower compared to the initial BioNTech shock (€1 billion vs. €3.175 billion), we conclude that the estimated fiscal policy response through the fiscal equalization scheme represents a similar, yet small-scale policy response as the initial shock.

Figure E.4: Fiscal equalization effects: Tax Rates

(a) Local business tax rate



(b) Property tax rate



F External Validity

Table F.1: 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)	Gladsaxe, 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 F.2: Studies in Meta Analysis

Study	Country	Estimates	Average estimate
Baskaran, 2016	Germany	1	0.92
Berset and Schelker, 2020	Switzerland	5	1.51
Berset, Huber, and Schelker, 2023	Switzerland	4	0.22
Brunner, Hoen, and Hyman, 2022	USA	1	1.27
Cascio, Gordon, and Reber, 2013	USA	1	0.50
Dahlberg et al., 2008	Sweden	1	1.30
Feiveson, 2015	USA	1	0.93
Feler and Senses, 2017	USA	1	0.37
Gadenne, 2017	Brazil	2	1.04
Helm and Stuhler, 2024	Germany	11	1.60
Heyndels and Van Driessche, 2002	Belgium	3	0.48
Litschig and Morrison, 2013	Brazil	1	1.16
Liu and Ma, 2016	China	1	1.11
Lundqvist, 2015	Finland	3	2.20
Lutz, 2010	USA	3	0.16
Martínez, 2023	Colombia	2	-0.01
Monteiro and Ferraz, 2010	Brazil	1	0.53
Rattsø and Tovmo, 2002	Denmark	3	0.29

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