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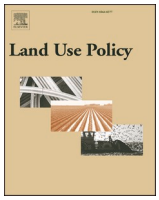

Building homes for tax revenues? Spatial evidence on the fiscal effects of residential land development

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ABSTRACT

This study quantifies the tax revenue effects of residential land development in Germany. Whereas existing research and policy debates have concentrated on the fiscal returns of commercial land expansion, the tax revenue effects of residential development remain largely unexplored. We estimate the impacts of increases in living space and settlement area on municipal tax revenues using spatial instrumental variable regressions and a nationwide cross-sectional dataset covering all German municipalities. Accounting for spatial spillovers and potential endogeneity, we document a significant positive effect of residential living space expansion on municipal income tax revenues, with substantial heterogeneity between urban and rural municipalities and across regions with differing economic performance. A corresponding analysis of broader settlement area expansion indicates similarly positive effects on total municipal tax revenues. Multiple robustness checks support the validity of these findings. Finally, we outline a simple framework for approximating the fiscal payback period of residential land development by relating estimated revenue effects to average municipal development costs.

1. Introduction

Housing shortages have re-emerged as a central policy concern in Germany. Current estimates suggest a deficit of roughly 700,000 dwellings (Guenther, 2023), and more than 9.5 million residents live in overcrowded housing according to the German Federal Statistics Office (Federal Statistical Office, 2025a). Referring to EU-SILC, this is defined as living space with no common room or no private room for children over 12 years of age (Eurostat, 2025). Despite sustained political attention and a federal target of constructing 400,000 housing units per year, actual completions have remained substantially below this benchmark (Bundesministerium für Wohnen, Stadtentwicklung und Bauwesen, 2025). Consequently, municipalities – who ultimately determine local land-use allocation – face mounting pressure to expand residential areas.

In the German context, municipalities exercise discretion over the local tax multipliers for both the business tax and the property tax, making these taxes important instruments of local fiscal policy. While property tax revenues result from both residential and commercial land, commercial development additionally generates business tax revenues, which are a major and relatively elastic source of municipal finance. This creates an asymmetry in fiscal incentives: the marginal revenue potential resulting from commercial land development can be higher and more immediate, whereas the fiscal returns resulting from residential development – primarily through property tax and the municipal share of income tax – are less direct and often perceived as weaker.

Residential and commercial land-uses are fundamentally interdependent. Municipalities require a stable resident population to supply labor, support local services, and sustain commercial activity, while households depend on proximity to employment opportunities and urban amenities. A balanced mix of both land-uses is therefore essential to maintain viable local economies. The challenge is not that municipalities disregard residential development per se, but that the fiscal benefits associated with commercial land-use are more visible and directly tied to municipal budgets, whereas the returns from residential development are more diffuse, accrue with a delay, and remain empirically underexplored.

This diffuseness has a mechanical explanation: the 15% municipal income tax share — Germany's primary residential revenue instrument — flows only to the municipality in which new residents formally register their primary residence, depends on the income distribution of those arrivals under a progressive rate schedule, and accrues with a delay of up to four years due to retroactive filing rules. Building a housing unit therefore generates no guaranteed fiscal return; the

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magnitude of that return depends entirely on who moves in, how much they earn, and where else they might have lived (the full mechanics are described in 3).

Despite the relevance of these fiscal incentives, surprisingly little is known about the magnitude of the fiscal returns resulting from residential land expansion in Germany. Existing evidence focuses predominantly on commercial development. Langer and Korzhenevych (2018), for instance, document that each additional square meter of commercial land increases municipal business tax revenue by approximately €13 in Bavaria, underscoring the financial attractiveness of commercial designations. Yet, no comparable evidence exists regarding the extent to which residential development contributes to municipal budget by leveraging income tax revenues, nor how these effects vary across different spatial contexts. This paper addresses these issues by quantifying the relationship between residential land development and municipal income tax revenues across all German municipalities. Given that housing construction is contingent on the availability of zoned residential land, understanding its fiscal impact is essential for assessing whether the perceived incentives align with actual revenue outcomes.

A standard fiscal impact assessment — estimating the number of new residents attracted by a development and multiplying their expected income by the applicable tax contribution per resident — is insufficient to answer this question reliably for three reasons. First, residential development in one municipality may attract residents who previously lived in a neighboring municipality, generating a spatial displacement effect rather than a net fiscal gain at the regional level: the gaining municipality benefits, but its neighbor loses the same taxpayer. Second, municipalities with stronger fiscal positions are more likely to invest in the infrastructure needed to open new land for development (Langer and Korzhenevych, 2018; Buettner, 2023), meaning that observed correlations between land expansion and tax revenues may partly reflect reverse causality rather than a causal fiscal return. Third, the magnitude of the income tax gain depends critically on the income profile of new residents: Germany's progressive income tax schedule implies that attracting higher-income households generates disproportionately larger municipal tax receipts. Accounting simultaneously for these spatial dependencies, potential endogeneity, and cross-sectional heterogeneity in household income requires a spatial instrumental variable regression framework.

Using a comprehensive dataset of 2016–2022 changes in municipal tax revenues, land development measures and control variables, we estimate spatial autoregressive and spatial instrumental variable models that account for regional heterogeneity, spatial spillovers, and potential endogeneity between land-use decisions and fiscal capacity. Our results show a robust positive association: a one square meter increase in living space is associated with a €47 increase in municipal income tax revenue, on average. To provide a point of comparison, we also examine how expansions in total settlement area – encompassing commercial, residential and infrastructure land – affect total municipal tax revenues.

By providing the first nationwide, spatially explicit evidence on the fiscal implications of residential development, our findings contribute to ongoing debates about local land-use incentives, housing supply constraints and municipal finance. They offer empirical grounding for evaluating whether local fiscal structures create distortions in zoning decisions and whether the long-run returns to residential land are stronger than commonly assumed. Germany offers an unusually informative setting for studying the fiscal effects of residential land development because municipalities face strong budgetary pressures but have limited tax instruments at their disposal. With income tax rates set federally and only the tax multipliers for business and property taxes under local control, population growth becomes one of the few channels through which municipalities can expand their long-run fiscal capacity. Germany therefore represents an ideal laboratory to quantitatively assess the impact of land development on tax revenues. However, the applied methodology can be adapted to other countries and regions, with any necessary country-specific adjustments .

Table 1
Variables and Rationales.

Variable	Category.	Rationale	Income tax estimation	Total tax estimation
Municipal income tax revenue in €	Taxation municipal-level dependent variable	Depicts change in largest person-related tax revenue in municipal budget	√	×
Total municipal tax revenue in €	Taxation municipal-level dependent variable	Represents change in total municipal revenue resulting from taxes	×	√
Built-up living space in m^2	Land-use municipal-level independent variable of interest	Measures changes in the housing stock and, therefore, the municipality's capacity to accommodate residents, i.e., taxpayers	√	×
Built-up settlement area in m^2	Land-use municipal-level independent variable of interest	Measures changes in the built environment and, therefore, the municipality's capacity to accommodate residents and firms i.e., taxpayers	×	√
Population density in inhabitants per km^2	Socioeconomic control variable	Agglomeration effects may increase tax revenues, e.g. because of higher income and business concentration (Luthi and Schmidheiny, 2014; Andersson, 2018)	√	√
Unemployment ratio in %-points	Economic control variable	Unemployed inhabitants of a municipality do not pay income tax, i.e. the higher the unemployment rate, the smaller the group of taxpayers and, vice versa, the lower the tax revenue	√	√
Share of houses out of all buildings in %-points	Land-use control variable	Single or double family homeowners tend to have higher incomes and wealth, which may result in higher tax revenues (Kuhn and Grabka, 2018);	√	√

(continued on next page)

Table 1 (*continued*)

Variable	Category.	Rationale	Income tax estimation	Total tax estimation
		at the same time indicator for changes in settlement structure		
Business tax multiplier in %-points	Taxation control variable	Higher business tax multiplier directly increases business tax revenue	×	√
Property tax (A) multiplier in %-points	Taxation control variable	Higher property tax multiplier directly increases property tax (A) revenue	×	√
Property tax (B) multiplier in %-points	Taxation control variable	Higher property tax multiplier directly increases property tax (B) revenue	×	√
Share of employees in the labor force by sector	Economic control variable	Proportions of economic sectors depict local economic structure, wage-levels and productivity between sectors may differ and thereby affect municipal tax revenues	√	√
Debt burden ratio in %-points	Economic control variable	Controls for tax revenue impacts of household debt, higher debt-levels may indicate lower income tax bases (French and McKillop, 2016)	√	√
Share of old population in %-points	Socioeconomic control variable	Proxy for non-working or part-time working populations, and thus for local employment, which in turn affects tax bases	√	√
Disposable household income per inhabitant in €	Socioeconomic control variable	Indicator of local purchasing power; increased purchasing power may translate into higher income and consumption taxes	√	√
GDP per capita in €	Economic control variable	Measure of local economic productivity that may influence municipal tax revenue	√	√
Transferred building land in 1000 m²	Land-use control variable	Monitors market activity in the local real estate market, which could have a particular impact on property and business taxes	√	√
Price for building land in € / m²	Economic control variable	Indicator of the local cost of living that could affect location decisions and thus tax bases	√	√
Municipal debt per inhabitant in €	Economic control variable	Municipal debt may affect the municipality's spending capacity and, consequently, firms' and residents' location decisions (Padovani et al., 2018)	√	√
Taxable turnover in 1000 €	Taxation control variable	Serves as a proxy for economic output; higher economic output may result in higher municipal business tax revenues (Langer and Korzhenevych, 2018)	×	√
Taxable turnover by sector	Taxation control variable	Accounts for size and structural changes in local economies that could be reflected in municipal tax revenues	×	√
Vegetation areas and green spaces 2016 in m²	Land-use instrumental variable	Serves as a proxy for the municipality's potential for expanding settlement and residential areas (in line with Langer and Korzhenevych, 2018)	√	√

This table presents all variables of our data set and the according rationale for including them in the given model specifications. Monetary variables are in nominal prices and in euro. All variables, except for the instrument, are reported as changes between 2022 and 2016.

Building on this motivation, we formulate three empirical hypotheses. H1: Residential land development has a significant positive effect on municipal income tax revenues, net of controls for local economic conditions and spatial interdependencies — tested in 5 and reported in Table 2. H2: Living space expansion in one municipality is associated with a negative spillover on income tax revenues of neighboring municipalities, consistent with the spatial displacement of taxpaying residents — tested via the indirect spatial impact measures in Table 3. H3: The positive fiscal return to residential development is larger in municipalities with higher average household incomes and in municipalities serving as local administrative and economic centers, reflecting income sorting and agglomeration effects — tested in 6.2 and reported in Tables 4 and 5.

The paper is organized as follows. 2 reviews the relevant literature and situates our contribution relative to existing empirical work on fiscal incentives and land development. 3 describes the German institutional setting — including the mechanics of municipal income tax distribution, the planning framework governing land designation, and the policy context — which motivates both our research question and our empirical approach. 4 details the data and variables. 5 presents the empirical strategy, including the spatial autoregressive model and the instrumental variable approach used to address potential endogeneity between land development and fiscal capacity. 6 reports the main results, spatial heterogeneity analyses, and a series of robustness checks. 7 discusses the fiscal payback framework and policy implications. 8 concludes.

2. Literature review

Having established in the Introduction that the fiscal returns to residential land development are largely unknown and that spatial spillovers and endogeneity require a regression-based approach, this section reviews what is known from the existing literature about the fiscal consequences of land-use decisions and identifies the gap our study addresses. Much of the classic literature on strategic fiscal interactions has focused on how jurisdictions compete on business taxation or public good provision (Wilson, 1999; Revelli, 2005), typically assuming local discretion over tax rates. Although this assumption does not apply to Germany's income tax system – where rates are federally set – the broader implications of fiscal interaction remain relevant. Yardstick competition models (Solé-Ollé, 2006; Bordignon et al., 2003) suggest that voters compare local fiscal performance to that of neighboring municipalities, generating political incentives that may influence land-use decisions even when local tax instruments are constrained.

More recent empirical contributions have begun to examine how fiscal incentives shape municipal land-use behavior. In Germany, Buettner (2023) provides causal evidence using a regression discontinuity design and shows that municipalities able to retain additional revenues — rather than having them redistributed to fiscally weaker municipalities through Germany's intergovernmental equalization system (described in 3) — convert significantly more agricultural land into residential and commercial uses. These findings resonate with research in other institutional settings: Gyourko and Krimmel (2021) document that greater local fiscal autonomy in the United States encourages more permissive zoning, while Getzner et al. (2025) find that fiscal surpluses in Austrian municipalities are associated with more extensive land consumption. Although these studies explain why municipalities may choose to expand residential or commercial land, they provide limited evidence on the fiscal consequences – particularly the tax revenue effects – of such expansions. Moreover, none of these studies incorporate a fully spatially explicit revenue analysis or examine how tax-base growth in one municipality may spill over to its neighbors. Our three empirical hypotheses (stated in 1) address precisely this gap: H1 tests whether the effect is positive on average, H2 tests whether spatial displacement of residents between municipalities partially offsets local gains, and H3 examines whether income sorting and agglomeration moderate the magnitude of that effect.

The literature is less conclusive regarding whether residential or commercial development is fiscally more advantageous for municipalities. Early German studies (Gutsche, 2003; Reidenbach et al., 2007; Krause-Junk, 2007) suggested that residential development can generate fiscal surpluses under certain conditions, especially in urban areas with strong labor markets. These studies, however, are limited by their regional focus and lack of controls for spatial dependencies or unobserved heterogeneity. More recent work applies more rigorous empirical methods. Clapp et al. (2018), for example, use panel fixed effects in a U.S. context and find that once city-specific heterogeneity is properly controlled for, the fiscal impacts of converting land to

Table 2
Effects of Residential and Settlement Land Development on Municipal Tax Revenues.

	Income tax Total Municipal Taxes				Total municipal taxes			
	(1) SAR	(2) SAR	(3) IV	(4) IV	(5) SAR	(6) SAR	(7) IV	(8) IV
Built-up living space	61.949***	61.671***	52.078***	60.180***				
	(4.949)	(5.024)	(2.752)	(3.389)				
Built-up settlement area					1.909**	2.057***	9.796***	14.146***
					(0.945)	(0.747)	(2.261)	(3.266)
Spatial parameter (ρ)	−0.127***	−0.127***	−0.051*	−0.116***	0.611***	−0.233	0.481***	−0.275
	(0.048)	(0.0049)	(0.027)	(0.044)	(0.142)	(0.206)	(0.134)	(0.205)
Municipal-level controls	No	Yes	No	Yes	No	Yes	No	Yes
County-level controls	No	Yes	No	Yes	No	Yes	No	Yes
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10,744	10,744	10,744	10,744	10,744	10,744	10,744	10,744
Sigma	1322,912	1299,901	1422,495	1301,775	22,907,127	19,566,642	23,557,175	21,228,697
AIC	333,389	333,028	334,949	333,059	394,664	391,304	395,266	393,056
BIC	333,520	333,275	335,080	333,306	394,796	391,632	395,397	393,984
First stage results								
Vegetation areas and green spaces 2016			0.0004***	0.0004***			0.0034***	0.0032***
			(0.0001)	(0.0001)			(0.0002)	(0.0002)
F-statistic			410.164***	573.729***			201.803***	184.573***

This table presents the results of spatial autoregressive regressions analyzing the impact of land development on municipal tax revenues. The dependent variable in models (1) to (4) is the change in municipal income tax revenue. The dependent variable in models (5) to (8) is the change in the total amount of municipal tax revenues. All variables, except for the instrument, are shown as differences between 2022 and 2016. Models (3), (4), (7) and (8) include an instrumental variable, which is not included in the second stage estimation of the models. Heteroskedasticity robust standard errors are in parentheses. Significance levels are indicated by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$.

Table 3
Spatial Impacts for Residential and Settlement Land Development and Municipal Tax Revenues.

	Income tax Total Municipal Taxes				Total municipal taxes			
	(1) SAR	(2) SAR	(3) IV	(4) IV	(5) SAR	(6) SAR	(7) IV	(8) IV
Direct impact								
Built-up living space	61.957***	61.679***	52.104***	60.273***				
	(4.937)	(4.964)	(2.626)	(3.583)				
Built-up settlement area					1.918**	2.057***	9.881***	14.159***
					(0.944)	(0.731)	(2.158)	(3.190)
Indirect impact								
Built-up living space	−6.995	−6.967**	−2.511*	−6.369***				
	(113.370)	(2.746)	(1.310)	(2.406)				
Built-up settlement area					2.991	−0.390	11.548	−2.762
					(9.629)	(0.365)	(15.944)	(2.676)
Total impact								
Built-up living space	54.961	54.712***	49.593***	53.904***				
	(113.454)	(3.388)	(2.144)	(2.427)				
Built-up settlement area					4.909	1.667***	21.429	11.397***
					(9.919)	(0.561)	(16.821)	(3.147)

This table presents spatial impacts of spatial autoregressive regressions analyzing the impact of land development on municipal taxes. The dependent variable in models (1) to (4) is the change in municipal income tax revenue. The dependent variable in models (5) to (8) is the change in the total amount of municipal tax revenues. Models (3), (4), (7) and (8) include an instrumental variable, which is not included in the second stage estimation of the models. The given coefficients refer to direct, indirect and total spatial impact measures, respectively. Heteroskedasticity robust standard errors are in parentheses. Significance levels are indicated by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$.

Table 4
Spatial Heterogeneity in Municipal Income Tax Estimation.

	Income tax Total Municipal Taxes Total Municipal Taxes								
	(1) County-equivalent cities	(2) Independent municipalities	(3) Associated municipalities	(4) Top 75% income	(5) Top 50% income	(6) Top 25% income	(7) Top 75% land prices	(8) Top 50% land prices	(9) Top 25% land prices
Built-up living space	38.132***	62.967***	63.821***	62.157***	57.681***	56.093***	−13.940	19.174***	29.088***
	(2.541)	(3.455)	(3.708)	(5.102)	(4.462)	(2.844)	(10.402)	(5.364)	(2.900)
Interaction term	29.238***	−36.942***	−45.655***	−2.026	5.255	16.498***	77.565***	45.980***	37.837***
	(6.265)	(7.587)	(9.708)	(8.469)	(8.582)	(4.825)	(12.534)	(7.688)	(5.559)
Municipal-level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County-level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Spatial parameter (ρ)	0.062*	0.036	−0.077**	−0.110***	−0.092***	−0.088***	−0.071**	−0.082**	0.033
	(0.032)	(0.033)	(0.036)	(0.038)	(0.032)	(0.023)	(0.035)	(0.036)	(0.032)
Observations	10,744	10,744	10,744	10,744	10,744	10,744	10,744	10,744	10,744
Sigma	1106,591	1184,296	1258,756	1316,329	1282,232	1241,984	1185,964	1164,500	1149,152
AIC	329,570	331,028	332,339	333,300	332,736	332,051	331,059	330,666	330,381
BIC	329,832	331,291	332,601	333,562	332,998	332,313	331,321	330,928	330,643
First stage results: Vegetation areas and green spaces 2016	0.0003***	0.0005***	0.0004***	0.0004***	0.0004***	0.0004***	0.0004***	0.0004***	0.0004***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
F-statistic	367.023***	609.677***	352.446***	573.809***	572.448***	564.674***	574.886***	577.894***	581.224***

This table presents the results of spatial autoregressive instrumental variable regressions analyzing the impact of living space development on changes in municipal income tax revenue. The dependent variable in models (1) to (9) is the change in municipal income tax revenue. All models include interactions with the referred dummy variables. Each column reports estimates from a separate regression, in which municipalities outside the category indicated in the column header form the reference group. The coefficient on living space development reflects the effect for the reference group, while the interaction term captures the differential effect for the category indicated in the column header; the total effect for that category is given by the sum of both coefficients within a column. All variables, except for the instrument, are shown as differences between 2022 and 2016. The instrumental variable is not included in the second stage estimation of the models. Heteroskedasticity robust standard errors are in parentheses. Significance levels are indicated by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$.

residential, commercial, or open space become statistically similar. These findings challenge the traditional assumption that residential land inherently burdens local budgets, although institutional differences – particularly the German system of income tax sharing between national and municipal budgets and its weaker residential property-tax base – limit the direct transferability of such results. The absence of comparable German evidence, despite clear theoretical reasons to expect both income tax and property tax effects resulting from residential expansion, represents a notable empirical gap.

Within the German context, evidence on revenue effects remains scarce. Langer and Korzhenevych (2018) estimate that each additional square meter of commercial land increases municipal business tax revenues by roughly €13 in Bavaria, highlighting the immediate fiscal attractiveness of commercial development. This study, however, is geographically limited to a single federal state, provides no nationwide estimates and does not account for spatial spillovers between

Table 5
Spatial Heterogeneity in Total Municipal Taxes Estimation.

	Total municipal taxes Total Municipal Taxes Total Municipal Taxes								
	(1) County-equivalent cities	(2) Independent municipalities	(3) Associated municipalities	(4) Top 75% income	(5) Top 50% income	(6) Top 25% income	(7) Top 75% land prices	(8) Top 50% land prices	(9) Top 25% land prices
Built-up settlement area	6.166***	36.813***	20.434***	8.472***	6.882	9.791***	−5.311	−0.490	3.152
	(2.010)	(9.510)	(6.368)	(3.279)	(4.340)	(3.476)	(5.080)	(2.301)	(2.071)
Interaction term	−3.953	−38.803***	−33.578**	32.562**	74.246**	94.190**	51.740***	63.582***	70.426***
	(8.365)	(11.943)	(13.164)	(12.895)	(31.451)	(46.108)	(12.066)	(13.829)	(18.590)
Municipal-level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County-level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Spatial parameter (ρ)	−0.099	−0.136	−0.234	−0.092	0.020	−0.043	−0.091	−0.050	0.235
	(0.189)	(0.206)	(0.194)	(0.156)	(0.152)	(0.142)	(0.213)	(0.220)	(0.176)
Observations	10,744	10,744	10,744	10,744	10,744	10,744	10,744	10,744	10,744
Sigma	18,330,420	24,205,624	22,989,818	22,424,077	21,037,969	21,155,072	24,264,046	23,811,740	22,630,697
AIC	389,904	395,878	394,771	394,235	392,864	392,984	395,930	395,526	394,432
BIC	390,246	396,220	395,113	394,578	393,207	393,326	396,272	395,868	394,775
First stage results:	0.0029***	0.0033***	0.0030***	0.0032***	0.0032***	0.0032***	0.0032***	0.0032***	0.0032***
Vegetation areas and green spaces 2016	(0.0002)	(0.0003)	(0.0003)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
F-statistic	151.972***	163.344***	134.221***	184.447***	184.905***	182.691***	184.596***	186.147***	185.732***

This table presents the results of spatial autoregressive instrumental variable regressions analyzing the impact of settlement area development on total municipal tax revenue changes. The dependent variable in models (1) to (9) is the change in the sum of total municipal tax revenues. All models include interactions with the referred dummy variables. Each column reports estimates from a separate regression, in which municipalities outside the category indicated in the column header form the reference group. The coefficient on living space development reflects the effect for the reference group, while the interaction term captures the differential effect for the category indicated in the column header; the total effect for that category is given by the sum of both coefficients within a column. All variables, except for the instrument, are shown as differences between 2022 and 2016. The instrumental variable is not included in the second stage estimation of the models. Heteroskedasticity robust standard errors are in parentheses. Significance levels are indicated by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$.

municipalities. Crucially, and despite the central role of housing in local fiscal capacity, there exists no empirical evidence at all on the fiscal returns on residential land development – neither statewide nor nationwide. In particular, how residential expansion affects the municipal income tax base, property tax capacity, or related revenues has not been studied systematically, leaving a major gap in understanding how land-use decisions translate into local fiscal outcomes. International studies indicate that the net fiscal effect of residential development is highly context-dependent – Yan et al. (2022), for instance, show that residential sprawl in China can generate fiscal stress – highlighting the importance of analyzing these relationships within the specific institutional environment of Germany.

From a tax policy perspective, Dolls et al. (2025) examine Germany's real estate transfer taxes (RETT) and find that increases in RETT are largely capitalized into lower home prices, with a one-percentage-point increase reducing prices by roughly three percent. These results are consistent with Eerola et al. (2021), who find that transfer taxes in Finland substantially reduce mobility, thereby exacerbating housing misallocation. Cho et al. (2024) use a calibrated overlapping-generations model to show that replacing stamp duties with property taxes improves welfare and mobility. While these studies deal primarily with tax incidence and behavioral effects, they confirm the importance of understanding how local tax regimes interact with housing markets – an angle we explore through the lens of spatial clustering of tax revenues and economic output.

Infrastructure and service costs are an essential component of this evaluation. Vermeiren et al. (2022) show that dispersed residential expansion in Flanders substantially increases infrastructure expenditures relative to compact development. U.S. studies (e.g., Burchell et al., 2005) similarly document that low-density growth patterns can increase annual local government deficits. These findings highlight that the fiscal implications of residential development cannot be assessed solely on the revenue side; the spatial form of development materially affects the municipal budget balance. By acknowledging the cost side, our study complements the revenue-focused evidence and links the fiscal analysis to broader urban development patterns.

Finally, the methodological sophistication of recent studies has improved the causal identification of fiscal effects. Dolls et al. (2025) use staggered difference-in-differences designs, Buettner (2023) applies regression discontinuity, and Fraenkel and Krumholz (2025) leverage exogenous school finance reforms to assess how fiscal compensation shapes local decisions. Spatial econometrics is also increasingly used to account for spillovers and spatial autocorrelation, particularly in studies like Getzner et al. (2025) and Ruettenauer and Best (2021). Our study builds on these methodological advances by applying spatial instrumental variable regressions to a nationwide cross-sectional dataset, enabling us to identify robust regional patterns and spatial dependencies that influence municipal tax revenues.

In summary, our study contributes to a growing body of literature concerned with the fiscal consequences of land-use. By focusing specifically on residential development and its effects on municipal income tax revenues across all German municipalities, we provide new empirical evidence that complements earlier regional or case-based research. Our approach also adds value by integrating cost-side considerations and offering policy-relevant insights into the financial sustainability of land development.

The comparison of empirical literature shows that existing studies either focus on commercial land (e.g., Langer and Korzhenevych, 2018), rely on regional case studies without nationwide coverage (Gutsche, 2003; Reidenbach et al., 2007; Krause-Junk, 2007), or analyze land-use incentives rather than fiscal returns (Buettner, 2023; Goetze and Hartmann, 2021). Importantly, no prior study provides nationwide evidence on the fiscal effects of residential land development in Germany, nor do existing studies combine causal identification with spatial econometric methods. To the best of our knowledge, our study is the first to address these dimensions simultaneously.

3. Institutional setting

Building on the research gap identified in the literature review, this section describes the institutional framework that governs both land development decisions and municipal tax revenues in Germany — the two variables at the center of our empirical analysis.

Germany comprises approximately 10,786 municipalities, ranging from rural communities of a few hundred inhabitants to cities of over one million. Despite their heterogeneity in size and economic profile, all municipalities share the same core fiscal and planning powers under federal law. Under the Federal Building Code, municipalities exercise exclusive authority over local land-use planning: they decide independently whether to designate greenfield or brownfield sites for residential, commercial, or mixed use, making them the primary decision-makers on residential land expansion. Governance structure varies between two main types. County-equivalent cities exercise both municipal and county-level functions and are fiscally self-contained. county-member municipalities belong to a county, which provides supra-municipal administrative services. In both cases, the core fiscal instruments — business tax, property tax, and the income tax share — are received at the municipal level. Municipalities are required to provide local infrastructure (e.g., roads, drainage, parks) and, in most cases, primary school buildings. The most expenditure-elastic services — secondary education, residential elderly care, and child protection — are primarily financed at the federal state or county level, which means that the fiscal incentive to attract high-income, low-service-demand households is real but partially moderated by this vertical cost-sharing structure.

If we disregard the subsidies that municipalities receive from the European Union, the federal government, and the federal states, for example to implement major infrastructure measures, the municipal budget is primarily defined by tax revenues. According to article 106 of the Basic Constitutional Law of the Federal Republic of Germany, tax revenues are divided between the federal government, the states, and the municipalities. The municipalities receive the total revenue resulting from business tax and property tax, as well as a proportionate share of revenue from income tax and value-added tax. Fig. 1 visualizes the average portions of tax revenues within municipal budget. Around 80 % of the municipal budget depends on how many companies and residents are located in the municipal area and the amount of tax they contribute.

The income tax is the largest person-related source of municipal revenue in Germany, constituting approximately one third of average municipal budgets over our sample period (see Fig. 1). According to the first paragraph of the Income Tax Act, all income of natural persons with their domicile or habitual residence in Germany is subject to the income tax. This includes income revenues from agriculture and forestry, commercial operations, self-employment, employment, capital assets, renting and leasing, as well as all other income sources. Income tax is a progressive tax, meaning that the tax rate increases gradually as income rises. While income below €12,000 is tax-free, the top tax rate is 45 % for taxable income above approximately €270,000. Income tax rates are uniform across the entire country. The distribution of income tax revenue is regulated in Article 106(5) of the Basic Constitutional Law of the Federal Republic of Germany. Therein, it is stated that tax revenues are to be distributed between the federal government, the federal states and the municipalities. The Municipal Finance Reform Act defines the municipal share of the income tax revenues at 15 %. Accordingly, 15 cents of every euro of income tax revenue are passed on to the municipality in which the taxpayer resides. Critically, this share is allocated to the municipality in which the taxpayer maintains their primary registered residence — not where they work. Municipalities therefore have no influence over income tax rates, which are set uniformly at the federal level with a progressive schedule; their fiscal interest lies entirely in attracting and retaining income-earning residents. Municipalities, therefore, have an incentive to develop land and designate building plots to increase their tax revenues. However, decisions on land development are more complex and the potential uses are not independent of one another.

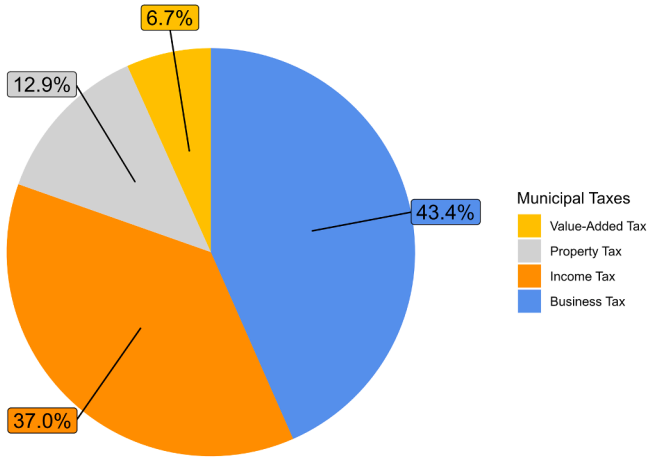

Fig. 1. Average Distribution of Tax Revenues in Municipal Budget 2016–2022
This figure displays a pie chart of average municipal tax revenues as parts of municipal budget. We present average values for the observation period from 2016 to 2022. Shown data are calculated as sample mean values. Data source: Federal and State Statistical Offices (2025a).

Business tax is the largest item in the municipal budget and accrues entirely to the municipalities. According to the Business Tax Act, any company or business based in Germany is subject to the business tax. Exceptions apply to specific industries, such as infrastructure services, and to small businesses. The tax rate is calculated in two steps based on a company's profit. In a first step, a tax base amount is calculated applying the federal tax rate of 3.5 %. This tax assessment rate is uniform across Germany. In a second step, the tax base amount is multiplied with a business tax multiplier set by each municipality. According to Article 106(6) of the Basic Constitutional Law of the Federal Republic of Germany, municipalities have the right to define the business tax rate individually. This enables municipalities to compete in terms of business tax rates.

Property tax revenues account for approximately 13 % of municipal budget. As with business tax revenues, property tax revenues are also allocated exclusively to the municipalities in which the taxable properties are located (Article 106(6) of the Basic Constitutional Law of the Federal Republic of Germany). The Property Tax Act stipulates that every property within a municipal area is subject to taxation. Exceptions apply to properties for special use, such as churches or public administration buildings. The amount of tax is calculated in two steps, like the business tax. In the first step, a tax assessment amount is calculated as a percentage of the property value. This percentage depends on the usage of the property and is standardized nationwide in the Property Tax Act. In a second step, the actual amount of tax is then determined by applying a multiplier. Municipalities set this multiplier individually. A distinction is generally made between a multiplier for agricultural and forestry land (multiplier A) and a multiplier for all other land (multiplier B).

The smallest share within municipal budget refers to the value-added tax (VAT). In principle, all commercial transactions are subject to the VAT. Exceptions apply to transactions that are subject to their own taxes, for example in the transport sector, as well as for specialized transactions listed in the VAT Act. The standard nationwide tax rate equals 19 %. A reduced tax rate of seven percent applies, for example, to sales of groceries. Revenue from VAT is divided between the federal government, the federal states, and the municipalities. The distribution ratio depends on the amount of revenue generated and is specified in the Fiscal Equalization Act. Within the sample, each municipality received, on average, approximately two percent of the VAT revenue generated within its municipal boundaries.

Two attribution rules govern which municipality receives which tax

revenue. For income tax, the principle of residence applies: a 15% municipal share flows to the municipality in which the taxpayer is formally registered as their primary residence under paragraph1(1) of the Income Tax Act. Taxpayers with multiple properties must declare one as primary; tax authorities have limited discretion to override self-reported registrations. For business tax, the principle of establishment applies: liability accrues to the municipality where the business is located, with multi-site firms apportioning tax across locations in proportion to payroll (paragraphs 28–29 Business Tax Act). One structural counterincentive operates through the horizontal fiscal equalization system: municipalities with above-average fiscal capacity transfer resources to below-average municipalities, partially clawing back the gains from a growing income tax base. Our revenue estimates throughout the paper should therefore be interpreted as gross effects; net effects, after equalization transfers, would be somewhat smaller in high-capacity municipalities.

In the context of this paper, it is also important to understand the role of municipalities in facilitating land development in Germany. Vacant greenfield or vacated brownfield sites are sold either by the municipality itself or private owners. Land developers are required to draw up and present land-use plans before municipal authorities grant permission based on these plans. Within the framework of their self-administration based on the principle of subsidiarity, municipalities decide whether to change the use of their municipal territory and, if so, in what form. Initiatives such as the EU Soil Strategy for 2030 (European Commission., 2021) seek to influence municipalities' decisions regarding sustainability. The Federal Government's German Sustainability Strategy (German Federal Government, 2025) envisages a reduction in the designation of building land, so that a circular economy for land could apply from 2050 onwards. Henger and Bizer (2010) propose tradable planning permits (TPP) as a market-based instrument for municipalities to steer land designation sustainably. Henger et al. (2023) demonstrate in a field experiment that permit trading can effectively redirect land development toward more sustainably located sites. Despite this evidence, TPP has seen limited adoption in practice — a difficulty that partly reflects the political economy of inter-municipal coordination. We accord TPP particular attention because our spatial spillover results provide a direct fiscal rationale for such coordination: if residential development in one municipality partly displaces taxpaying residents from its neighbors, then uncoordinated municipal planning generates fiscal externalities that supra-municipal mechanisms like TPP are designed to internalize. This sustainability imperative stands in direct tension with the federal government's Bauturbo initiative. In November 2023, the federal government agreed a broad pact with the federal states to radically accelerate planning and approval procedures, aiming to reduce the time from planning decision to building permit and to enable residential construction under simplified conditions (Bundesministerium für Wohnen, Stadtentwicklung und Bauwesen., 2024). This policy direction has been actively reinforced in 2025 accelerating housebuilding as a centerpiece of the current government's housing agenda. The co-existence of a binding land-take reduction target and an accelerated construction mandate illustrates the central policy dilemma our paper addresses: without evidence on the fiscal returns to residential development, municipalities cannot rationally weigh the environmental cost of greenfield conversion against its fiscal benefit.

The municipality is obliged to consider the interaction between different types of land-use in its land development plans. Residential areas, commercial areas, public infrastructure and natural areas are interdependent. Residential areas require commercial areas for local supply and to generate livelihoods. Commercial spaces, in turn, require employees and customers in the surrounding area to survive. Both residential and commercial areas require infrastructure. This, in turn, must be created and maintained by the municipality from its budget and, consequently, from its tax revenues. The municipality's urban land-use planning pursues two major goals. First, to create sufficient living space for its inhabitants. Second, generating sufficient tax revenue to maintain infrastructure and operate sustainably. While empirical evidence on the impact of commercial zoning on tax revenues is already available for the second objective (see Langer and Korzhenevych, 2018), there is a lack of research on the impact of residential zoning on municipal budgets.

The following analysis therefore quantifies the impact of residential development on municipal income tax revenues and compares this with the change in municipal revenues resulting from the general expansion of settlement areas, which includes not only residential areas but also commercial areas and infrastructure.

4. Data description

4.1. Municipal income tax

The institutional mechanisms described in 3 — in particular the residence-based allocation of the municipal income tax share — make the change in municipal income tax revenues a direct measure of the fiscal return to residential land development. This section describes the data used to operationalize this relationship across all German municipalities.

The income tax represents the largest person-related tax revenue in the municipal budget. Within our sample period, ranging from 2016 to 2022, it is also the second largest amount of all municipal revenues. Fig. 1 shows, that about one third of the revenues of municipalities in Germany results from income taxation. The data on the municipal income tax revenue is retrieved from the Federal and State Statistical Offices (Federal and State Statistical Offices, 2025a). It covers 10,744 out of 10,786 municipalities in Germany. Missing municipalities are either not permanently domiciled and therefore do not impose income tax, or they do not disclose data on a regular basis. The retrieved sample covers the change in income tax revenue from 2016 to 2022. The data set is limited to this time frame because no more recent data was available at the time of analysis. One important reason for this is likely to be the possibility of filing a tax return retroactively for up to 4 years, stated in the Federal Tax Code. Therefore, definitive statistics on income tax revenues are regularly only available with a delay of four years. The data series is also limited in terms of historical availability, as in 2016 public statistics were converted from the automated property register to the official land cadaster information system. This change in data collection causes a structural break in the time series of public statistics. The surfaces and borders of municipalities have been recalculated, making it impossible to compare them with earlier data (Georg, 2016).

Fig. 2 visualizes the data coverage and the change in municipal income tax revenues within the sample period for every municipality. Increases in income tax revenues, marked with darker color, as well as spatial clustering are particularly visible in metropolitan areas in the western and southern parts of Germany, as well as in the capital city Berlin in the north-eastern part.

4.2. Total municipal taxes

To enable a comparative analysis of the impact of land development on municipal tax revenues, the total tax revenues of municipalities in Germany are examined in addition to income tax revenues. Fig. 1 shows that business tax revenues are the most important share within municipal budget. Property tax and value-added tax complement the municipality's revenue alongside the income tax, whose institutional mechanics are described in 3. The total municipal tax revenues equal the sum of the four tax revenues depicted in Fig. 1. The data on the municipal business tax revenue as well as on business tax multipliers is, similarly to the income tax revenue data, retrieved from the Federal and State Statistical Offices (Federal and State Statistical Offices, 2025a). Table A1 reports descriptive statistics. The change in tax multipliers within the sample period appears rather small, while the business tax revenues are reported as part of the total municipal tax revenues. The

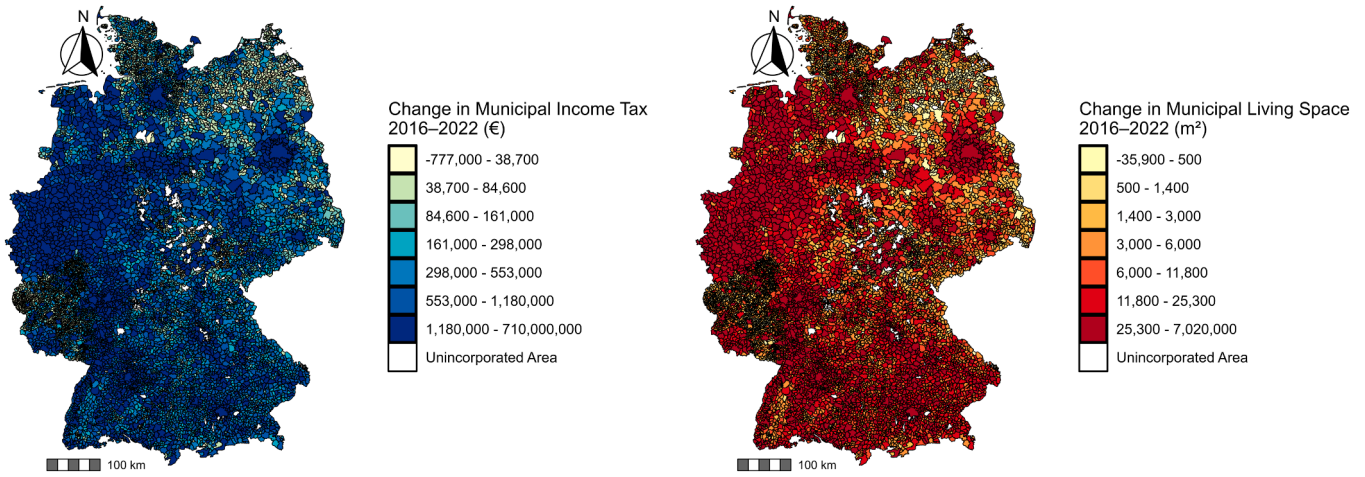

Fig. 2. Change in Municipal Income Tax Revenue and Living Space 2016−2022 This figure displays the change in municipal income tax revenues in € between 2016 and 2022 on the left, and the change in municipal living space in m^2 between 2016 and 2022 on the right. Darker color refers to higher tax revenues increases and higher increases in living space, respectively. Data sources: Federal and State Statistical Offices (2025a) & Federal and State Statistical Offices (2025b).

data on property tax revenues and tax multipliers is gathered from Federal and State Statistical Offices (2025a). The changes within the sample, shown in Table A.1, indicate that the multipliers are rarely adjusted and largely kept constant. The data on VAT revenues is retrieved from Federal and State Statistical Offices (2025a).

Fig. 3 visualizes the data coverage and the change in total municipal tax revenues within the sample period for every municipality. Increases in tax revenues, marked with darker color, are again particularly visible in metropolitan areas in the western and southern parts of Germany, as well as in the capital city Berlin in the north-eastern part. Fig. 3 also makes spatial clustering in terms of higher and lower changes in tax revenues apparent.

4.3. Residential land consumption

Residential land consumption is measured as the change in living space in each of the 10,744 municipalities in Germany during the sample period 2016–2022. Living space is defined as the sum of the floor areas of all rooms in an apartment or house. The data on living space is gathered from the residential building and housing stock statistics based on the German Census (Federal and State Statistical Offices, 2025b). This data is updated annually and published with a time delay of about two to three years. An increase in living space results from the construction of new buildings on land that was previously not used for residential purposes, or only to a limited extent. Similarly, the conversion of buildings, as well as extensions and additions, increase the amount of living space within a municipality. Fig. 2 depicts the change in municipal living space in square meters (m^2) for the sample period 2016–2022. While living space increased in most municipalities, some municipalities are experiencing a decline in living space resulting from the demolition of buildings, especially in northeastern Germany. The map visualizes higher increases in living space in darker color. Spatial clustering of higher increases in living space is observed especially around metropolitan areas, like Berlin in the northeastern part or Munich in the southeastern part of Germany.

In the following analysis of municipal income tax revenues, residential land consumption is the independent variable of interest. We aim to estimate the effect of each additional square meter of living space on a municipality's income tax revenue. Also, we analyze the extent to which the municipal income tax revenue effect resulting from the expansion of living space is affected by local conditions, such as household income levels, building land prices, or geographical location. In line with Langer and Korzhenevych (2018), we expect significant spatial heterogeneity in the municipal income tax revenue effects across municipalities.

4.4. Settlement area land consumption

Settlement area land consumption is measured as the change in settlement area within the sample period. Settlement area comprises areas dominated by buildings for residential and commercial use, as well as for infrastructure and open spaces in the context of settlement, in particular sports and leisure areas and green spaces. Data on municipal settlement area is derived from Federal and State Statistical Offices (2025c). An increase in this area results from the development of land for settlement purposes or from the conversion of previously agricultural or unused natural areas. Fig. 3 visualizes the change in settlement area within the sample period as well as the data coverage for 10,744 out of 10,786 municipalities. The map chart shows an increase in settlement area for most municipalities, with some exceptions in the eastern part of Germany. Like residential areas depicted in Fig. 2, Fig. 3 shows spatial clustering around metropolitan areas, even though the clusters stand out comparatively less from the overall picture.

In the analysis of total municipal taxes, the change in settlement area is the independent variable of interest. Developed areas can either be used for residential purposes, thereby increasing income tax revenues by accommodating more residents, or they can enable commercial settlements or expansions, thereby increasing commercial and sales tax revenues. In addition, the development of previously undeveloped or sparsely developed areas could increase property tax revenues, as the tax is primarily based on the building area. However, we expect the effect of settlement area expansion on total municipal tax revenue to be significantly smaller than the effect of living space increase on municipal income tax revenue, because settlement areas, unlike living spaces, include substantial areas designated for infrastructural purposes that do not initially contribute to tax revenue.

4.5. Control variables

An analysis of areas in Germany at the regional level, focusing on municipalities, reveals a complex and highly heterogeneous picture. German municipalities range from rural regions with sparse populations outside of agglomerations to urban metropolises with supra-regional conurbations and several million inhabitants in densely populated areas. Therefore, land-use does not proceed in isolation, but is shaped by heterogeneous requirements regarding size, amenities, infrastructure, and other factors that vary locally. The consequences of land development, including the tax implications that are at the heart of this analysis, may vary accordingly. 3 outlines the assessment of municipal taxes depending on individual economic parameters. If two municipalities

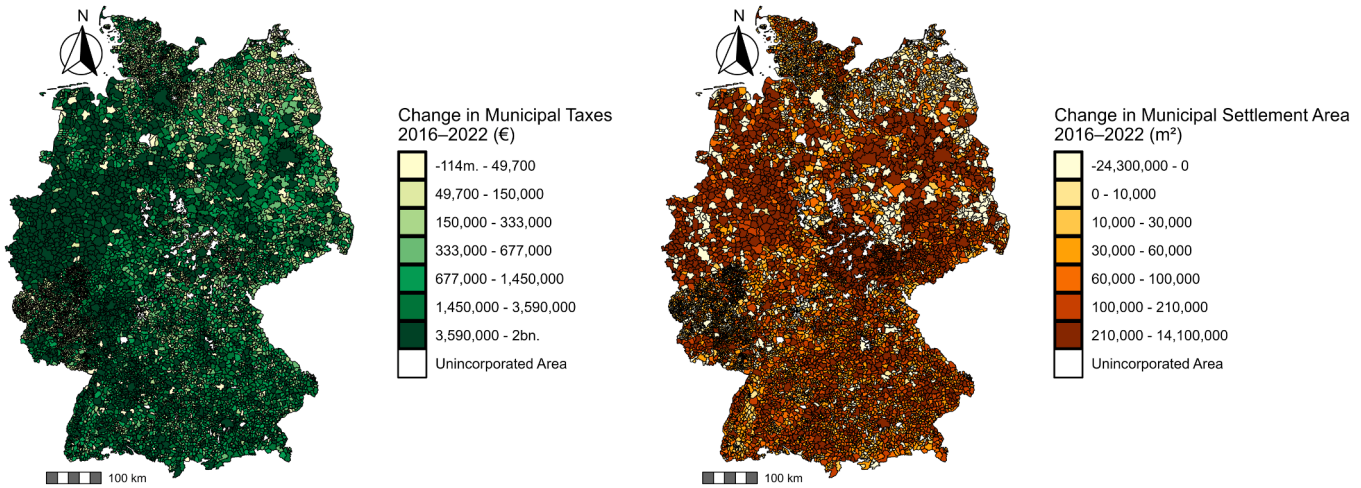

Fig. 3. Change in Total Municipal Tax Revenue and Settlement Area 2016−2022 This figure displays the change in total municipal tax revenues in € between 2016 and 2022 on the left and the change in municipal settlement area in m² between 2016 and 2022 on the right. Darker color refers to higher tax revenue increases and higher increases in settlement area, respectively.

with different demographic or economic characteristics undertake the same land development, the fiscal consequences are likely to differ, as these may depend on a variety of local factors, such as household composition, income level, business productivity, or infrastructure provision. To control for potential influences of heterogeneity in municipal characteristics on tax revenues, we include municipal and county-level control variables. Table 1 provides an overview of all variables applied and the rationale for their inclusion in the estimation of municipal tax revenue changes.

The change in population density is included to control for agglomeration effects (i.e. higher income sorting and productivity concentration) reported in earlier studies of Luthi and Schmidheiny (2014) and Andersson (2018). Population density is measured as inhabitants per square kilometer and derived from Federal and State Statistical Offices (2025d). The unemployment rate is included as an indicator for economic prosperity and derived from Federal and State Statistical Offices (2025e). We expect an increase in the unemployment rate to be negatively associated with tax revenues, because unemployed inhabitants of a municipality do not pay income tax. The higher the proportion of unemployed residents in a municipality, the smaller the group of taxpayers and, vice versa, the lower the tax revenue. Furthermore, to control for the effect of settlement structures on tax revenues, we include the change in the share of single and double family houses out of all buildings within a municipality into our analysis. This variable is calculated as the ratio between the number of single and double family houses and the total number of buildings. The data is derived from Federal and State Statistical Offices (2025b). We expect higher shares of houses to be positively associated with tax revenues, because Kuhn and Grabka (2018) find evidence for single or double family homeowners to have higher incomes and wealth, which, in turn, result in higher tax revenues.

As business and property tax revenues are calculated applying multipliers set individually by municipalities, we include the tax multipliers for business tax, agricultural and forestry property tax (A) as well as for all other property tax (B). The calculation method for these taxes suggests a direct correlation between the multiplier and tax revenue, and, therefore, potential reverse causality. Given the absence of significant changes in tax multipliers during the observation period (see Table A1), we, however, refrain from adjusting these variables. Bénassy-Quéré et al. (2007), Hassett, Brill, (2007) as well as Langer and Korzhenevych (2018) propose a possible way of addressing reverse causality in tax multipliers using time-delayed variables. Regarding data availability, applying this method would have in turn required a shorter observation period. Because the observation period is already limited due to data collection by statistical offices, time-delayed variables were not incorporated in favor of a longer observation period.

At a more aggregated level, we also include county-level data. In accordance with the principle of subsidiarity, smaller and more rural municipalities are assigned to higher-level counties that take on administrative tasks, while larger cities are independent and form their own county in terms of administration. We derive data on employment from (Federal and State Statistical Offices, 2025; Federal and State Statistical Offices, 2025i) and include changes in the share of employees in different industries, including manufacturing, construction, trade and tourism, finance, services, and agriculture, to control for local economic structures. The change in the average debt burden ratio is included to control for tax revenue impacts of household debt, since French and McKillop (2016) find evidence for a significant relationship of indebtedness and household income. Data is derived from Creditreform Wirtschaftsforschung (2022). Other socioeconomic control variables include changes in the old-age dependency ratio (Federal and State Statistical Offices, 2025 f), average household income (Federal and State Statistical Offices, 2025 g), and GDP per capita (Federal and State Statistical Offices, 2025 h). The amount of transferred building land and the average transaction price of building land are taken from Federal and State Statistical Offices (2025i) and changes in these variables are included to map regional property prices using proxy variables. Following the evidence of Padovani et al. (2018), changes in the municipal debt per inhabitant is included to address potential impacts of the municipality's financial health on firm locations and tax revenues. Data on municipal debt is gathered from Federal and State Statistical Offices (2025j). We are further in line with Langer and Korzhenevych (2018) by applying changes in taxable turnover as well as the contribution of individual economic sectors to taxable turnover as additional control variables for local economic conditions in some model specifications. Data on economic output is taken from Federal and State Statistical Offices (2025k).

Table A1 contains descriptive statistics for the cross-sectional data set. All data is reported as difference between 2022 and 2016. The variation in variables is significant because of the heterogenous characteristics of observed municipalities in terms of size, settlement, economic structure as well as geographic properties. We aim for a complete analysis of the German spatial structure and control for neighborhood effects. Therefore, we refrain from removing any outliers from the data set. To map the complex spatial differences among German municipalities, we apply a broad set of control variables. The combined

application of a range of economic, social, and financial variables, however, poses the risk of multicollinearity and redundancy. We performed initial tests for multicollinearity by calculating pairwise correlations and variance inflation factors to minimize resulting biases in estimated coefficients. Indications of multicollinearity were addressed by removing correlated variables from the estimation model. Instead of including both the share of workers in the manufacturing sector and the share of workers in the processing sector simultaneously, for example, only one of the two correlated variables is included in the model to avoid redundancy. The resulting data set, displayed in Table 1 and Table A1, contains no signs of multicollinearity or redundancy.

5. Empirical analysis

5.1. Spatial regression approach

The data described in 4 display pronounced spatial clustering (see Figs. 2 and 3), which motivates the spatial regression framework developed in this section. A closer look at the map sections in Fig. 4 confirms this observation. The upper row shows substantial clustering of income tax revenues around Berlin. The lower row shows weaker and smaller clusters for total tax revenues in the state of Bavaria. We first establish the presence of spatial autocorrelation, then specify the spatial autoregressive model, and finally explain the instrumental variable strategy used to address the potential endogeneity of land development decisions.

Earlier studies of Buettner (2003) on spatial dependencies of local tax revenues and Bénassy-Quéré et al. (2007) on local tax competition already provide indications for a spatial component to explain local tax revenues. More recent studies of Janeba and Osterloh (2013) on business tax competition and Trojanek et al. (2021) on spatial patterns in property taxes strengthen this approach. For an analytical assessment of visually observed spatial clusters, we apply Moran's′ I test on spatial autocorrelation, first developed by Moran (1950). The test statistics appear highly significant for income tax revenues and total municipal tax revenues (see Table A2 and Table A3).[1] The identified spatial autocorrelation appears to be global rather than local. That is, spatial clusters of higher or lower tax revenues extend beyond directly neighboring municipalities. Spatial clustering occurs across multiple municipal boundaries, particularly in metropolitan areas. In line with the approach of Otto and Schmid (2018) dealing with German municipal data, we employ a spatial weight matrix for neighboring properties based on inverse distances. The characteristics of neighboring municipalities are given greater weight the nearer they are located to a given municipality under investigation. The shapefile used to compile the neighborhood matrix was taken from Federal Agency for Cartography and Geodesy (2025). The maximum distance at which neighborhood effects can be identified in terms of municipal tax revenues is 50 kilometers.

To analyze the effect of residential land development on municipal income tax revenues and the expansion of settlement areas on total municipal tax revenues, a spatial autoregressive model (SAR) is estimated in a first step. The global neighborhood effects identified in the preliminary analysis and the established neighborhood matrix are thereby considered. The spatial patterns of tax revenues and land development are approximately identical and primarily determined by metropolitan regions and conurbations. The spatial structure of the data is, therefore, addressed autoregressively for the dependent variable. This approach is based on the findings of Anselin (1988), LeSage and Pace (2009) and Elhorst (2014), which justify a one-time addressing of approximately identical spatial patterns to avoid overfitting and distortions. Consequently, there is no separate control for spatial autocorrelation in the land development variables alone. We apply the following baseline regression Eq. (1):

$$\Delta \mathrm{Tax}_i = \rho \sum_{j=1}^{N} (W_{i,j} \Delta Tax_j) + \beta \Delta AREA_i + \sum (\gamma_i \Delta \mathrm{C}_i) + \delta_i + \epsilon_i \quad (1)$$

.

where $\Delta \mathrm{Tax}_i$ refers to the dependent variable, i.e. the municipal income tax revenues or the total municipal tax revenues, respectively. The independent variable $\Delta AREA_i$ indicates the developed living space or settlement area, respectively. C_i refers to a $1 \times K$ vector of municipal-level and county-level control variables in a municipality *i*. Table 1 gives an overview of which control variables are included in what model specification. δ_i denotes federal state fixed effects. The sum of $W_{i,j} \Delta Tax_j$ describes the properties of neighboring municipalities. W represents the inverse-distances neighborhood matrix, wherein $W_{i,j}$ is the i,jth element of that matrix ($i, j = 1, \ldots, N$). ρ measures the response factor with neighboring municipalities. ϵ_i refers to the error term.

We include federal state fixed effects in all model specifications to control for unobserved heterogeneity, such as differing local regulations, topography or exogenous shocks. Heteroskedasticity robust standard errors are applied in all model specifications.

5.2. Endogeneity and instrumental variable

Based on previous studies on the relationship between land development and tax revenues, there is reason to believe that not only does land development influence tax revenues, but tax revenues also influence land development. In this case, the explanatory variables for land development could not be considered entirely exogenous. Song and Zenou (2006) empirically prove the interdependence of property taxes and urban sprawl in the US. Chapman and Gorina (2012) find evidence for the simultaneity of municipal revenues and infrastructure expenditures. Langer and Korzhenevych (2018) argue that the designation of industrial and commercial land may be dependent on the financial health of municipalities due to the obligation of the municipality to provide necessary infrastructure.

As it cannot be ruled out that there exists a degree of simultaneity between municipal tax revenues and land development, the coefficients of the SAR regression could be estimated in a distorted manner. An instrumental variable estimation can be used to address this endogeneity issue. To conduct an unbiased estimation, the explanatory variables for changes in living space and settlement area must be represented by instruments that are not related to municipal tax revenues. We are in line with Langer and Korzhenevych (2018), who analyze the impact of the expansion of commercial space on business tax revenues of municipalities in the state of Bavaria, using an instrumental variable estimation. Within their study, open space area is applied as an exogenous instrument for commercial space expansion. Using a similar approach, we apply the vegetation area available within municipal boundaries in 2016 as an instrument for both the change in living space within a municipality and the change in the settlement area of a municipality. Vegetation area is defined as the sum of all areas within municipal boundaries that are not used for settlement or infrastructure purposes. This includes agricultural land, forests, heaths, moors, marshlands and other areas without vegetation. Data on municipal vegetation area is taken from Federal and State Statistical Offices (2025c). However, the available government data makes no distinction as to whether vegetation areas are subject to protection. It therefore cannot be ruled out that protected areas for flora and fauna—such as those designated as Natura 2000 conservation areas in Germany under European Union Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora—are included within the total area of vegetation. In line with Langer and Korzhenevych (2018), we argue that the

[1] The test statistic is relatively low, but consistently significantly different from zero. According to Zhang et al. (2019), a declining test statistic with an increasing number of observation points in the spatial sample is methodologically determined.

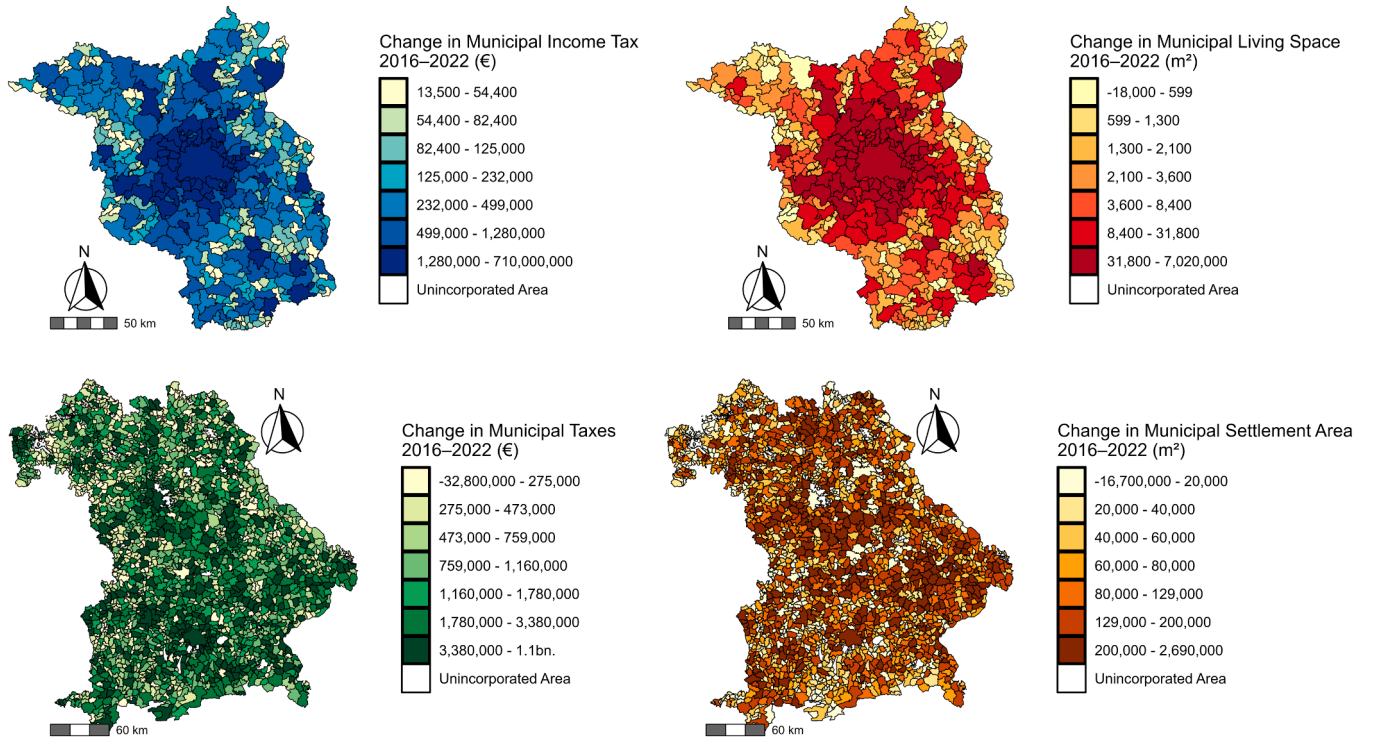

Fig. 4. Spatial Dependencies Exemplary for Berlin and Bavaria 2016−2022 This figure displays the change in municipal income tax and total municipal tax revenues in € between 2016 and 2022 in the first column, and the change in municipal living space and municipal settlement area in m² between 2016 and 2022 in the second column. Darker color refers to higher tax revenue increases and higher increases in settlement area, respectively. The maps in the first row show the federal states of Berlin and Brandenburg, while the maps in the second row show the federal state of Bavaria. Data sources: Federal and State Statistical Offices (2025a), Federal and State Statistical Offices (2025b) and Federal and State Statistical Offices (2025c).

vegetation area within a municipality simultaneously represents the municipality's potential for expanding settlement and residential areas. The potential presence of areas designated for nature conservation and environmental protection within the total vegetation area does not inherently reduce this potential, as construction and development projects are permissible in protected areas, provided their environmental compatibility can be demonstrated (see paragraph 34 of the Federal Nature Conservation Act). Furthermore, the municipality's tax revenues are not reliant on its vegetation areas. The only exception to this applies to agricultural land, for which property tax is assessed.[2] We, therefore, expect a significant positive relationship between vegetation area and living space expansion, as well as between vegetation area and settlement area expansion.

The derived instrumental variable is integrated into the existing methodology using the two-stage least squares method. The potentially endogenous variable is applied to the instrument and all control variables in the first stage. Eq. (2) shows the functional form of the first stage regression model:

$$\Delta AREA_i = \alpha VEG_i + \sum(\mu_i \Delta C_i) + \delta_i + \nu_i \tag{2}$$

where $\Delta AREA_i$ refers to the change in living space or settlement area, respectively. VEG_i is the instrument representing municipal vegetation area in 2016. C_i refers to a $1 \times K$ vector of municipal-level and county-level control variables in a municipality i. δ_i denotes federal state fixed effects., ν_i refers to the error term.

In the second stage, we replace the potentially endogenous explanatory variable ($\Delta AREA_i$) with the fitted values of the first stage regression ($\widehat{\Delta AREA_i}$). In addition, the spatially lagged dependent variable $W_{i,j}\Delta Tax_j$ is treated as endogenous. The model is therefore estimated using a generalized spatial two-stage least squares (GS2SLS) approach, in which both $\Delta AREA_i$ and $W_{i,j}\Delta Tax_j$ are instrumented. This results in the functional form as follows:

$$\Delta \text{Tax}_i = \rho \sum_{j=1}^{N} (W_{i,j}\Delta Tax_j) + \beta \Delta \widehat{AREA}_i + \sum(\gamma_i \Delta C_i) + \delta_i + \epsilon_i \tag{3}$$

where ΔTax_i represents the dependent variables of interest, which are municipal income tax revenue or total municipal tax revenues, respectively. The explanatory variables of interest, change in living space and change in settlement area, are included using instrumental variable estimation. Identification is achieved by instrumenting $\Delta AREA_i$with the external instruments and their spatial lags, and by instrumenting the spatially lagged dependent variable $W_{i,j}\Delta Tax_j$ with spatial lags of the exogenous variables. To allow for an assessment of instrument validity, the estimation results of the first stage regression as well as the corresponding Kleibergen-Paap F-statistics are displayed in the following regression outputs.[3]

6. Results

6.1. Estimated effect of land development on municipal tax revenues

We report the results of the spatial IV models specified in 5, testing each of the three hypotheses stated in the Introduction in turn. The estimation results for the spatial autoregressive models and the instrumental variable regression models are reported in Table 2. Therein,

[2] The revenue that municipalities derive from agricultural property tax is however so small that it can be disregarded at this point.

[3] The Kleibergen-Paap F-statistic allows to perform an econometric test to check whether the impact of the instrument is significantly different from zero. See Kleibergen and Paap (2006) for a detailed derivation.

columns (1) to (4) report the results of the income tax estimation while columns (5) to (8) contain the estimated coefficients on the total tax revenue of municipalities.

The estimated coefficient on the change in living space on income tax revenue is consistently significant and, as expected, positive. We provide the coefficients of the spatial autoregressive models for comparison but focus on the instrumental variable estimates because of the potential bias in spatial autoregressive models. The instrument is statistically significant throughout and, as expected, results with a positive coefficient. Furthermore, the Kleibergen-Paap F-statistic is significantly greater than the value of 10, indicating, according to Kleibergen and Paap (2006), the strength of the instrument. Spatial impacts are calculated to interpret the coefficients of the spatial autoregressive estimates. These are calculated by applying the neighborhood matrix and the estimated spatial parameter and are categorized as direct, indirect, and total effects. We report spatial impacts in Table 3. Direct impacts depict the effect of an independent variable on the dependent variable within a municipality. Hence, the coefficient on the change in living space within a municipality increases from 52 €/m² without including control variables to about 60 €/m² when including control variables. The indirect impact refers to the effect of the independent variable of one municipality on all neighboring entities. Referring to models (3) and (4), the indirect effect is significantly negative. Hence, an increase in living space in one municipality results in a decrease in income tax revenues of neighboring municipalities. This is a slight indication of tax competition between municipalities. The negative effect could result from taxpayers moving to housing in neighboring municipalities, causing the municipality of their former place of residence to lose tax revenue. The sum of direct and indirect effect, the total impact, can be interpreted as marginal effect. The nominal coefficient on the change in living space increases from 50 €/m² to about 54 €/m² when including control variables. Considering the cumulated inflation rate of 15.2 % for the period from 2016 to 2022 (Federal Statistical Office, 2025b), there remains a real increase in the municipality's income tax revenue of, on average, 47 euros per square meter of additional living space (ceteris paribus).

The change in unemployment rate per capita as well as the change in debt burden ratio show a negative relationship with income tax revenues, while changes in population density, old age dependency ratio and the average transaction price for building land yield positive coefficients. Significance of these variables is, however, unstable. The change in the amount of transferred building land shows a significant negative relationship with income tax revenues, as expected. Contrary to expectations, significant negative relationships emerge between the change in the proportion of houses in a municipality and the change in average household income. This effect could arise, for example, from larger income disparities within a municipality, which are smoothed out in the average household income. Further explanations could lie in tax avoidance strategies employed by higher income groups, who reduce their taxable income, for instance, through real estate investments. We report the coefficients on all control variables in Table A4.

Models (5) to (8) provide the estimated coefficients on the impact of settlement area development on total municipal tax revenues. Focusing again primarily on the instrumental variable regressions, the coefficient on settlement area development appears to be consistently and significantly positive. The results of the first stage and the Kleibergen-Paap F-statistic also show that the instrument is relevant and strong in the context of settlement area and its influence on tax revenues. However, the spatial coefficient switches sign and comes out insignificant. This also results in only the direct and total spatial impacts being highly significant. Within a municipality, an increase in settlement area by one square meter results in an average nominal increase in total municipal tax revenues of €10 without applied control variables and €14 with control variables applied. The neighboring effects (indirect impacts), however, result slightly insignificant and are therefore not interpreted. Considering the aggregated inflation rate of 15.2 % (Federal Statistical Office, 2025b), the direct effect of an increase in settlement area by one square meter results in an increase in total municipal tax revenue of €12 in 2016 prices. Referring to applied control variables, changes in population density and taxable turnover show significant positive coefficients and are in line with expectations. Furthermore, the change in transferred amount of building land as well as the change in municipal debt result in significant negative coefficients, which is also in line with expectations. Similar to the first regression on the impact of living space expansion on income tax revenue, changes in household income display a significant negative impact. This could, again, result from income concentration, distortions within average household income, or tax avoidance strategies. All coefficients are reported in Table A5.

6.2. Spatial heterogeneity

The consideration of a large number of heterogeneous cities and municipalities raises the question of how generally observed effects vary between individual regions. Furthermore, findings from earlier studies suggest that the impact on municipal tax revenues varies depending on local conditions. The study by Langer and Korzhenevych (2018) demonstrates that business tax revenues are higher in urban areas than in rural areas. Agrawal and Shybalkina (2023) confirm this observation by analyzing municipal tax revenues generated from retail businesses. Anastasiou et al. (2024) further prove the sensitivity of local tax revenues to local conditions, particularly regarding the economic structure of regions.

We analyze the extent to which the effects of land development on municipal tax revenues differ because of the functional role of municipalities within agglomerations in a first step. For this purpose, we create a categorical variable based on a municipality's administrative status which serves as a proxy for the centrality and urbanity of municipalities. As outlined in 3, municipalities can be categorized into larger cities with county-equivalent status and municipalities belonging to a county that consolidates administrative tasks within its jurisdiction, based on their urban character and economic prominence within agglomerations. The Federal Agency for Cartography and Geodesy (2024) further subdivides county-affiliated municipalities based on their economic and administrative capacity. Independent municipalities fulfil a central role within agglomerations, but delegate certain administrative tasks to higher-level county administrations due to efficiency considerations. Associated municipalities are subordinate entities within settlements whose administration is handled by community institutions at a broader level. In the following, we distinguish between county-equivalent cities, independent county-affiliated municipalities, and smaller associated municipalities within counties.

Fig. 5 shows the distribution of the outlined administrative statuses of municipalities in Germany. It becomes evident that densely populated county-equivalent cities are primarily located in western Germany. Moreover, agglomerations are apparent around major German cities. Creating an interaction term from the categorical variables and the independent variables on the change of living space or the change of settlement area results in positive coefficients only in urban municipalities of central roles within agglomerations. Table 4 shows the results of regressions with interaction terms for income tax revenues, while Table 5 shows the results of total municipal tax revenues.[4] Even though the possibilities for land development in already urbanized areas are limited, this observation seems plausible. Income and commercial

[4] We report two coefficients in each column. Built-up living space and built-up settlement area refer to the effect of living space development on income tax revenue changes and settlement land development on total municipal tax revenue changes, respectively. The coefficient on the interaction term refers to how the impact on tax revenues changes in a region of interest. The sum of both coefficients refers to the impact on tax revenue changes in the region of interest, addressed by the interaction term.

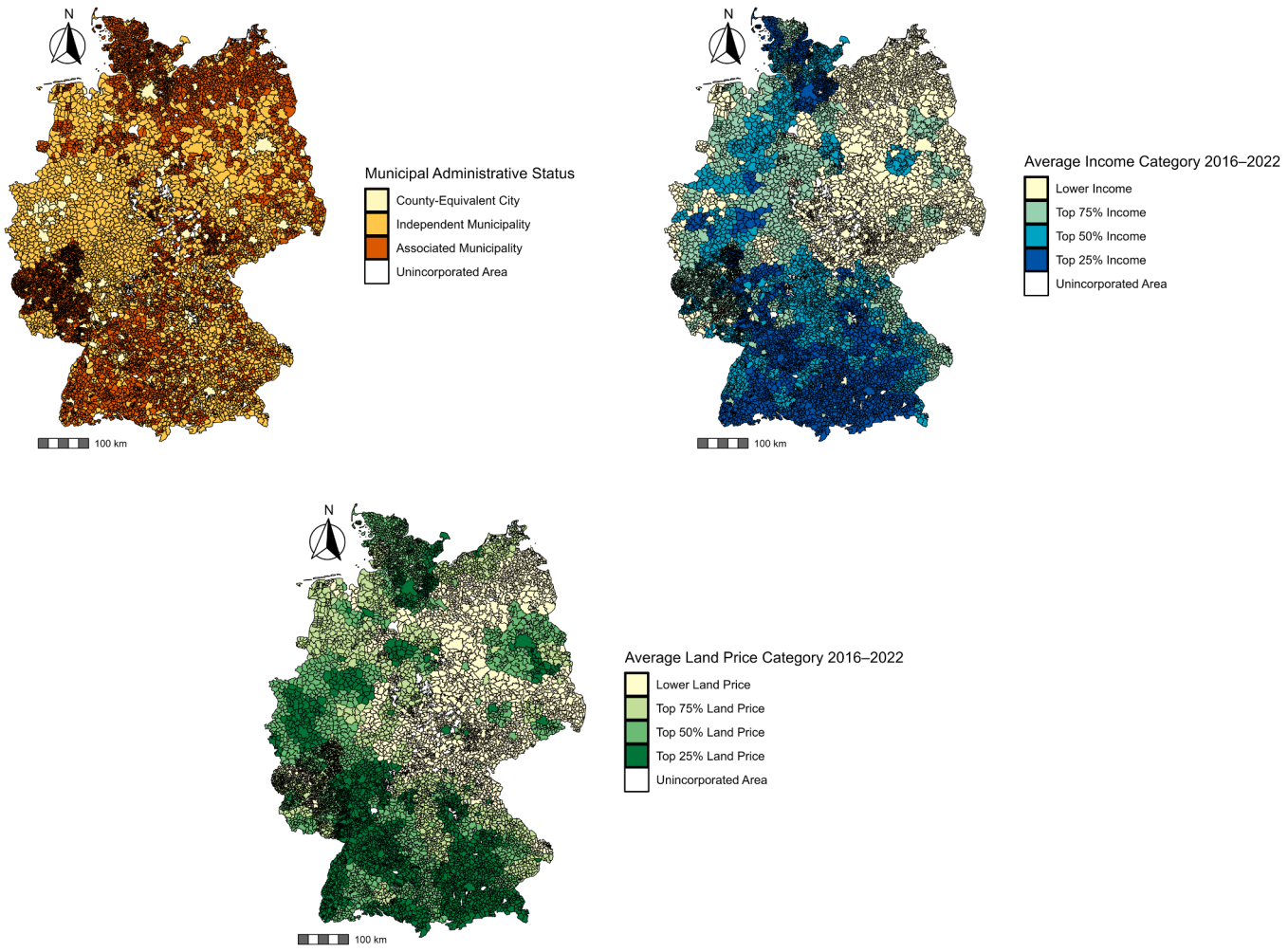

Fig. 5. Spatial Heterogeneity. This figure displays categorial variables for administrative status, household income and building land prices on a municipal level. Sample averages were applied to create categorical variables. Data sources: Federal Agency for Cartography and Geodesy (2024), Federal and State Statistical Offices (2025) g) and Federal and State Statistical Offices (2025i).

turnover are usually higher in central urban areas than in rural areas of minor regional importance (Gornig and Goebel, 2018; Ahrend et al., 2014).

In a second step, we examine whether the average income level has an impact on municipal tax revenues. We, therefore, form quartiles of the sample average disposable income of households per capita. The lowest first quartile serves as the reference category. Fig. 5 shows the spatial distribution of the average disposable income in the sample. This reveals that there is some overlap between urban municipalities of higher administrative status with higher income regions. However, some more rural regions of associated administrative status also show high incomes, particularly in the southern and northernmost parts of Germany. Table 4 shows that only in municipalities belonging to the highest income quartile, a significant coefficient on the interaction term is achieved. The positive coefficient illustrates that the designation of living space in municipalities with above-average disposable household income is expected to generate particularly high-income tax revenues from the municipality's perspective. Looking at the effect of settlement area expansion on total tax revenue reported in Table 5, it is evident that the coefficients on all interactions with income quartiles are significantly positive. However, again, the coefficient on the highest income quartile is the largest.

We analyze the extent to which the local price level of building land affects the impact of land development on municipal tax revenues in a third step. Fig. 5 shows the spatial distribution of the categories formed for average building land prices in Germany. The map shows that urban municipalities with county-equivalent administrative status and municipalities with higher household incomes also tend to have higher building land prices. However, considerable differences are evident as well. Municipalities in southern and northeastern Germany, for instance, tend to have higher building land prices, even though they are neither urban and of higher administrative status within agglomerations nor do they show higher household incomes. This could possibly result from local geographic conditions or infrastructure advantages that increase the price of building land. Running the regression with interaction terms on the categories of building land prices reveals a nuanced picture. While the coefficients on the interaction terms of building land price categories and living space designation reported in Table 4 are consistently significantly positive, the absolute magnitude of the effect of living space designation on income tax revenue hardly changes. A different picture emerges for the coefficients on the effect of settlement area designation on total municipal tax revenues, moderated by the categories of building land prices, as reported in Table 5. In municipalities with higher average building land prices, the effect of designating settlement areas on municipal tax revenues increases.

6.3. Robustness checks

To ensure that the coefficients determined using spatial regression methods are robust, various tests and changes are made to the model

setup in the following. All robustness checks are performed both for the estimation of municipal income tax revenues and for the estimation of total municipal tax revenues.

In a first step, a so-called Queen's neighborhood matrix is used instead of the inverse distance-based neighborhood matrix to address the neighborhood relationships between municipalities.[5] This matrix specifies first-order neighborhood interdependencies whenever two municipalities share a common border, regardless of its length. This test serves to verify whether the coefficients determined on the variables of interest, namely built-up living space and built-up settlement area, depend mainly on the configuration of neighborhood relationships between municipalities. However, the coefficients on the variables of interest shown in the first column of Table 6 and Table 7 are likewise positive and significant at the 1% level. Furthermore, the instrument is positive and significant in the first stage in both model configurations, and the Kleibergen-Paap F-statistic continues to confirm the instrument's relevance.

In a second step, we divide the sample time series into two subsamples. A first sub-sample is formed for the period from 2016 to 2019. A second sub-sample is formed analogously for the period from 2020 to 2022. On the one hand, this test serves to examine the dependence of the results on the selection of a specific time period. On the other hand, dividing the sample by year serves to isolate any potential influence of the COVID−19 pandemic. Clemens and Veuger (2020) forecast declines in tax revenues, particularly in income tax and VAT, due to falling employment figures and declining purchasing power. Chernick et al. (2020) reinforce this forecast and extend it with decreases in property tax. In an initial analysis, Funke and Terasa (2022) determine that short-term reductions in VAT, as seen in Germany at times during the pandemic, initially cost the governments in Germany losses in tax revenue, but that these could be offset by catch-up effects. Fig. 6 shows the changes in income tax revenues and living space in German municipalities for the two subsamples. No significant differences in local dynamics are apparent. Referring to the scales of the diagrams, however, growth in the second subsample spanning from 2020 to 2022 is lower than in the first subsample spanning from 2016 to 2019.[6] The estimated coefficients on the impact of living space designation on income tax revenue reported in Table 6, in columns (2) and (3), remain positive and significant. The spatial parameter turns slightly insignificant but remains negative. The instrument remains significantly different from zero and relevant.

Fig. 7 shows a comparative representation of changes in total tax revenues and changes in settlement area between the subsamples. Similarly, little change in dynamics is apparent. The development of settlement areas stagnates somewhat from 2020 onwards, but only in the central and eastern parts of Germany. Table 7 shows the results of subsample regressions. Columns (2) and (3) reveal that the estimated coefficient on the development of settlement area on total municipal tax revenue declines from 2020 onwards. At the same time, the sign of the spatial coefficient turns negative. This suggests that from 2020 onwards, competition arises between municipalities that had previously benefited from agglomeration effects.

In a third step, we divide the sample along the former inner-German border to analyze whether any lasting effects of the former division of Germany are apparent in terms of tax revenue analysis.[7] Findings by Bach et al. (2013) regarding income tax revenues in eastern and western Germany after the reunification of the two German states suggest that differences persist. Bossler and Schank (2023) furthermore demonstrate lower wage levels in eastern Germany, which in turn affect income levels, and, therefore, the income tax base. The study by Mertens and Mueller (2022) also suggests differences in business tax revenues, as it demonstrates an east-west divide in terms of taxable turnover. Figs. 6 and 7 show the course of the former inner-German border marked in red and blue color, respectively. In terms of income tax revenue and living space development, visualized in Fig. 6, growth in the former GDR is lower than in western Germany. The metropolitan region around Berlin is a clear exception. The illustration of changes in total tax revenue and settlement area development, shown in Fig. 7, reveals similar trends. Table 6 shows the results of the subsamples divided along the former inner-German border in columns (4) and (5). The coefficient on the effect of living space designation on income tax revenue is significantly positive in both eastern and western Germany but is greater in absolute terms in the western German subsample than in the eastern German subsample. The instrumental variable is again significantly positive in the first stage, and relevant. The spatial coefficient is significantly negative in the East German subsample, while it is positive but insignificant in the West German sample. This might result from tax competition in eastern Germany on the one hand, but also from the agglomeration effects of the capital city Berlin on the other.

The persistent east-west divide visible in Figs. 2, 3, 6, and 7 reflects three mutually reinforcing mechanisms. First, wage levels in eastern Germany remain substantially below western levels even three decades after reunification (Dickey and Widmaier, 2021; Bossler and Schank, 2023), directly reducing the income tax base available to eastern municipalities. Second, the horizontal fiscal equalization system provides eastern states with substantial intergovernmental transfers that cushion low own-source revenues — but simultaneously reduce the marginal incentive for eastern municipalities to expand their residential tax base, since a larger base reduces equalization entitlements. Third, demographic decline across much of eastern Germany structurally limits demand for new housing, constraining the revenue gains achievable through residential development. Together, these three mechanisms may explain why the regression coefficients on living space expansion are substantially smaller in eastern Germany than in western Germany across all specifications, reported in Tables 6 and 7.

However, the spatial coefficient might also change because of the lack of neighborhood relationships beyond the former inner-German border in this specification. Regarding the effect of settlement area expansion on total tax revenue, Table 7 shows the results of the subsample regressions for eastern and western Germany. This reveals a noticeable difference in the size of the coefficient on settlement area development. The coefficient is substantially larger in western Germany than in eastern Germany. Both coefficients are, however, significantly positive and different from zero. The instrumental variable also remains robust in terms of relevance and significance in the first stage.

In a fourth step, we combine the subsampling by period and by region of the former division of Germany from steps two and three. This allows for a more granular analysis of influencing factors on the main results. Table 6 shows the results of the analysis of income tax revenues in columns (6) to (9). The picture from the previous robustness checks is confirmed. While the coefficients on the expansion of living space are significantly positive in all model specifications, higher coefficients are evident in western Germany. In addition, significantly negative neighborhood effects emerge in eastern Germany. The instrument remains robust in all specifications. The results for total tax revenue differ somewhat and are presented in Table 7. Columns (6) to (9) show the results of the combined subsamples. The coefficients on the effect of settlement area development on tax revenue are consistently positive and significant but lose their significance in the eastern German sample from 2020 onwards. Neighborhood effects appear positive in the first period of the sample and turn significantly negative again after the onset of the COVID−19 pandemic. The instrumental variable remains robust

[5] The name Queen Matrix refers to the comparison with chess, in which the queen figure can move to any directly adjacent square in a single move (Cliff and Ord, 1981).

[6] The small differences may also result from the short time spans and long development periods in construction.

[7] Berlin is assigned to the territory of the former GDR, particularly regarding neighborhood relations. We thus follow the approach of Sunel and Grundke (2025).

Table 6
Robustness Tests of Municipal Income Tax Estimation.

	Income tax Total Municipal Taxes Total Municipal Taxes								
	(1) First order neighborhood matrix (queen)	(2) 2016–2019	(3) 2020–2022	(4) West Germany	(5) East Germany	(6) 2016–2019 West Germany	(7) 2020–2022 West Germany	(8) 2016–2019 East Germany	(9) 2020–2022 East Germany
Built-up living space	61.765***	80.045***	91.627***	64.581***	46.419***	91.359***	97.882***	59.402***	73.362***
	(3.834)	(4.794)	(6.647)	(3.348)	(2.256)	(5.650)	(6.792)	(3.719)	(6.418)
Municipal-level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County-level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Spatial parameter (ρ)	−0.0073**	−0.068	−0.019	0.040	−0.117***	0.094*	0.160**	−0.122***	−0.109**
	(0.0031)	(0.049)	(0.042)	(0.062)	(0.032)	(0.055)	(0.065)	(0.044)	(0.046)
Observations	10,744	10,744	10,744	8369	2375	8369	8369	2375	2375
Sigma	1299,480	1246,280	757,609	1198,190	741,081	1121,518	769,052	791,088	380,788
AIC	333,021	332,123	321,427	258,049	70,964	256,942	250,627	71,274	67,801
BIC	333,269	332,370	321,675	258,246	71,103	257,139	250,824	71,413	67,940
First stage results:	0.0004***	0.0002***	0.0001***	0.0006***	0.0001***	0.0003***	0.0002***	0.0001***	0.0001***
Vegetation areas and green spaces 2016	(0.0001)	(0.0000)	(0.0000)	(0.0001)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
F-statistic	573.729***	374.448***	694.848***	666.701***	41.549***	425.383***	767.665***	31.008***	80.345***
Spatial impacts:									
Direct impact	61.880***	80.435***	91.124***	64.471***	46.347***	91.326***	97.595***	59.126***	72.970***
Built-up living space	(3.658)	(4.579)	(6.752)	(3.457)	(2.378)	(5.859)	(6.564)	(3.671)	(6.119)
Indirect impact	−0.454**	−4.897	−1.440	3.164	−4.459	9.717	19.381**	−6.387**	−7.140**
Built-up living space	(0.202)	(3.750)	(3.679)	(4.116)	(3.775)	(5.963)	(9.443)	(2.622)	(3.321)
Total impact	61.426***	75.538***	89.684***	67.636***	41.888***	101.043***	116.976***	52.739***	65.830***
Built-up living space	(3.560)	(4.199)	(6.538)	(4.266)	(3.952)	(6.269)	(11.268)	(3.165)	(4.757)

This table presents the results of robustness tests applying spatial autoregressive instrumental variable regressions to analyze the impact of living space development on changes in municipal income tax revenue. The dependent variable in models (1) to (9) is the change in municipal income tax revenue. For the full-period specifications, all variables, except for the instrument, are shown as differences between 2022 and 2016; for the sub-period specifications, variables are expressed as differences over the respective intervals indicated in the column headers. The instrumental variable is not included in the second stage estimation of the models. Heteroskedasticity robust standard errors are in parentheses. Significance levels are indicated by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$.

in the estimation of total tax revenues.

The robustness checks show that the results of the analysis of total municipal tax revenues are, to a certain extent, driven by positive effects in western Germany. This evidence corresponds to the existing literature on the continuing influence of the former division of Germany on municipal tax revenues (see Bach et al., 2013; Bossler and Schank, 2023; and Mertens and Mueller, 2022). Furthermore, neighborhood effects in municipal tax revenues are evident, as expected. These vary across regions and change over time.

7. Discussion: economic efficiency and sustainability of land development

The results in 6 confirm a significant positive fiscal return to residential and settlement land development and reveal important spatial heterogeneity. This section translates these findings into a practical payback framework and discusses their implications for municipal planning policy and the long-run fiscal sustainability of residential development.

Earlier studies of Gutsche (2003), Reidenbach et al. (2007) and Krause-Junk (2007) demonstrate the incentive for municipalities to designate building land to generate tax revenue. More recent studies of Langer and Korzhenevych (2018) and Buettner (2023) prove increased tax revenues resulting from land development. The results of our analysis on income tax revenues, reported in Tables 2 and 3, demonstrate that each square meter of living space designation results in additional income tax revenues of €47. A similar analysis of total municipal tax revenues reveals around €12 in additional tax revenue per square meter of developed settlement area. Our findings thus clearly indicate that the development of living space can result in significant revenue increases for municipal budgets. Even though the development of an additional square meter of living space may require the creation of supporting infrastructure — which explains why the estimated tax revenue effect for settlement area is significantly smaller than the effect for living space development alone—it would be negligent to disregard this revenue potential in urban planning. Based on the results shown, developing commercial land does not appear to provide a clear fiscal incentive for municipalities in Germany in terms of tax revenue compared to residential land-use. Even though a sustainably developed municipality needs a balanced mix of residential and commercial areas (see 1), an equal consideration of both land uses in terms of municipal tax revenue appears appropriate. Assessing potential tax revenues prior to land-use decisions should involve a comparative analysis of both business tax revenues and income tax revenues to avoid creating misleading incentives. Compared to simple cost-benefit analyses based on static indicators, the spatial regression model described above demonstrates substantial advantages when estimating tax revenues resulting from land-use decisions. Dynamic changes in observation periods and geographic examination areas may be modeled, along with spatial relationships between examined entities, regional disparities, and concurrent effects of various influencing factors.

Besides potential tax revenue, designating settlement areas in general, or living spaces in particular, also entails land development costs for the municipality. Paragraph 123 of the Building Code stipulates that the municipality is responsible for developing land and maintaining its infrastructure. According to an older but very detailed breakdown by Koeller and Henger (2010), the municipality's development costs include expenditures for traffic infrastructure, drainage, lighting, green spaces, compensation and planning. In terms of economic sustainability, it is therefore important for municipalities to assess the balance between potential income and expenditure. Calculating the payback period provides an appropriate option for this consideration, when assuming constant tax revenues. Considering a municipality’s capital costs for development expenditures and inflation-based indexing of potential tax

Table 7
Robustness Tests of Total Municipal Taxes Estimation.

	Total municipal taxes Total Municipal Taxes Total Municipal Taxes								
	(1) First order neighborhood matrix (queen)	(2) 2016–2019	(3) 2020–2022	(4) West Germany	(5) East Germany	(6) 2016–2019 West Germany	(7) 2020–2022 West Germany	(8) 2016–2019 East Germany	(9) 2020–2022 East Germany
Built-up settlement area	27.477***	14.781***	7.750**	58.380***	2.164**	23.309***	110.850***	4.651***	1.293
	(5.705)	(2.710)	(3.249)	(10.869)	(0.956)	(6.045)	(36.218)	(1.263)	(0.882)
Municipal-level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County-level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Spatial parameter (ρ)	−0.079***	0.1549	−0.617*	−0.001	−0.086	0.266	−0.362	0.166*	−0.218***
	(0.027)	(0.169)	(0.339)	(0.307)	(0.076)	(0.252)	(0.335)	(0.088)	(0.075)
Observations	10,744	10,744	10,744	8369	2375	8369	8369	2375	2375
Sigma	26,160,100	10,101,493	19,831,398	28,111,574	6138,674	10,027,269	31,361,390	5077,710	4438,498
AIC	397,545	377,098	391,593	310,874	81,018	293,619	312,705	80,116	79,477
BIC	397,872	377,425	391,921	311,148	81,220	293,894	312,980	80,319	79,679
First stage results:	0.0032***	0.0019***	0.0010***	0.0023***	0.0037***	0.0013***	0.0005***	0.0020***	0.0013**
Vegetation areas and green spaces 2016	(0.0002)	(0.0001)	(0.0002)	(0.0002)	(0.0006)	(0.0001)	(0.0001)	(0.0004)	(0.0005)
F-statistic	184.573***	153.826***	28.226***	205.336***	33.661***	183.227***	26.770***	22.749***	6.870**
Spatial impacts:									
Direct impact	27.917***	14.844***	7.786**	57.967***	2.163**	23.274***	109.964***	4.634***	1.237
Built-up settlement area	(5.433)	(2.665)	(3.172)	(10.549)	(0.913)	(6.170)	(36.617)	(1.282)	(0.922)
Indirect impact	−1.900	3.121	−3.008	6.806	−0.159	168.631	−19.041	1.071	−0.246
Built-up settlement area	(2.584)	(3.949)	(1.903)	(187.140)	(0.331)	(2630.210)	(90.104)	(1.278)	(0.246)
Total impact	26.017***	17.966***	4.778***	64.774	2.003**	191.905	90.923	5.705***	0.997
Built-up settlement area	(5.443)	(4.396)	(1.810)	(188.688)	(0.853)	(2630.804)	(90.697)	(1.878)	(0.752)

This table presents the results of robustness tests applying spatial autoregressive instrumental variable regressions to analyze the impact of settlement area development on changes in total municipal tax revenues. The dependent variable in models (1) to (9) is the change in the sum of total municipal tax revenues. For the full-period specifications, all variables, except for the instrument, are shown as differences between 2022 and 2016; for the sub-period specifications, variables are expressed as differences over the respective intervals indicated in the column headers. The instrumental variable is not included in the second stage estimation of the models. Heteroskedasticity robust standard errors are in parentheses. Significance levels are indicated by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$.

revenues, the following baseline Eq. (4) allows for a consistent comparison of initial costs and potential tax revenues resulting from land development by expressing both sides in present-value terms.

$$\sum_{t=1}^{t^*} \frac{TR_{m,t}}{(1+i)^t} \widehat{=} \frac{I_0(1+r_f)^{t^*}}{(1+i)^{t^*}} \tag{4}$$

.

Therein, $TR_{m,t}$ represents the potential tax revenue of the municipality m as a function of time t. i denotes the discount rate or, in the illustrated case, the inflation rate. I_0 describes the initial investment of the municipality for the development of land. r_f denotes the capital costs of the municipality. Rearranging the formula for t^* allows to determine the period when tax revenues reach the expenditures for land development.

We provide a numerical example to calculate the payback period of living space development in a municipality, assuming fixed municipal costs and constant tax revenues. We, thereby, apply our main results, reported in Tables 2 and 3, and use the cost indicators derived from Koeller and Henger (2010) adjusted to the reference year of our analysis, 2022.[8] The development costs per square meter of living space amount to around €226. Assuming an inflation rate of two percent and municipal capital costs of 2.5 %, this results in a payback period of approximately 4.5 years.[9] Repeating the calculation for the profitability of general settlement area expansion in relation to total tax revenue of a municipality results in a payback period of approximately 9.2 years.[10] Using a comparable approach, Langer and Korzhenevych (2018) determine a payback period of seven years for industrial and commercial areas. These areas are part of the settlement area we analyze. Accordingly, the proximity of the determined payback periods appears plausible. However, these illustrative examples must be interpreted with caution. Potential tax revenues can vary substantially in time and spatial terms, as described in 6.2. The potential for income tax revenues is, for example, higher in central urban areas than in rural areas of minor regional importance. In addition, the costs incurred by municipalities for land development differ substantially depending on the region. Holcombe's and Williams' (2008) analysis of municipal cost structures, for instance, reveals that municipal size and population density have a significant impact on the expenditures required to maintain municipal infrastructure. Goodman (2019) also shows that the expense of creating

[8] We use the Federal Statistical Office (2025c) construction price index for adjustment.

[9] We use the European Central Bank inflation target rate of two percent per annum as a discount rate (European Central Bank, 2025). We use the yield on 30-year government bonds of around 2.5 % at the end of the reference year as an example for the interest rate for long-term investments (German Federal Bank, 2025).

[10] We, again, apply our main results reported in Tables 2 and 3. We furthermore assume the development costs for general settlement area to be around 40 % of the costs for living space designation, in line with Koeller and Henger (2010).

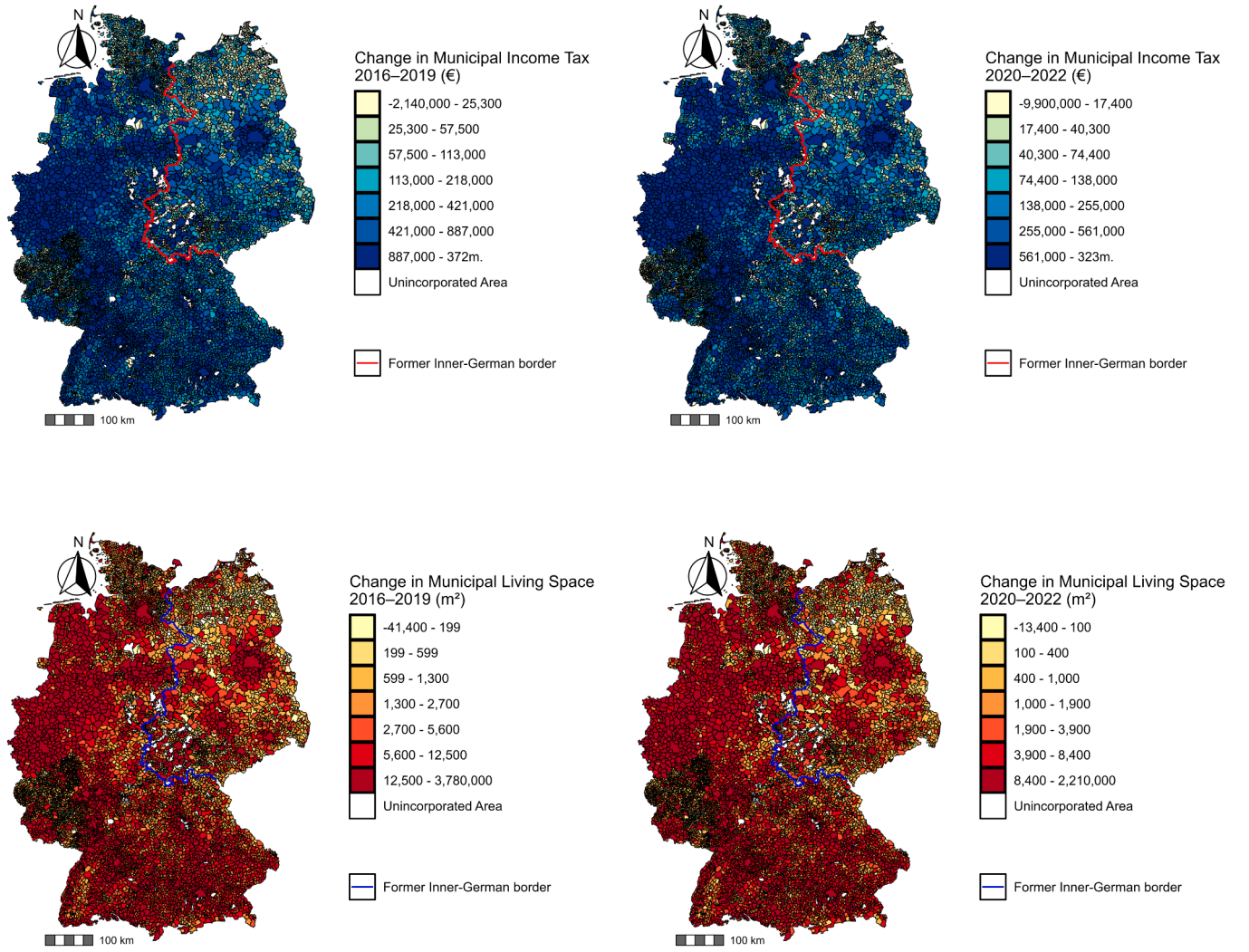

Fig. 6. Sub-Sampling of Income Tax Revenue and Buil-Up Living Space. This figure displays the change in municipal income tax revenues in € between 2016 and 2019 on the left, and the change in municipal income tax revenues in € between 2020 and 2022 on the right in the top row. In the bottom row, the change in municipal living space in m^2 is depicted between 2016 and 2019 on the left side and between 2022 and 2022 on the right side. Darker color refers to higher tax revenue increases and higher increases in living space, respectively. The course of the former inner-German border is shown in red color in the top row and in blue color in the bottom row. Data sources: Federal and State Statistical Offices (2025a) & Federal and State Statistical Offices (2025b).

and maintaining infrastructure depends crucially on the extent of urban sprawl.

Several important caveats apply to this payback estimate. Our calculation assumes constant annual tax revenues and static development costs, whereas the empirical literature — particularly from the United States — suggests that the long-run fiscal trajectory of low-density residential development is often negative. Burchell et al. (2005) document that sprawl development substantially increases cumulative infrastructure expenditures relative to compact growth. Holcombe and Williams (2008) show that larger, lower-density municipalities face systematically higher per-capita costs for maintaining roads, utilities, and public services. Goodman (2019) demonstrates that the long-run expenditure burden of aging suburban infrastructure can more than offset short-run revenue gains. Applying these insights to Germany, our 4.5-year estimate should be understood as a lower bound: municipalities that designate low-density residential land on the urban fringe may face significantly longer effective payback periods as infrastructure maintenance costs accumulate and the resident cohort ages — reducing income tax contributions while increasing demand for locally co-financed services. Our results therefore support residential land development most clearly in urban and higher-income contexts, where density, centrality and income levels combine to produce higher revenues and lower per-unit infrastructure costs.

A further structural qualification concerns the expenditure side. Even if residential development generates a positive short-run fiscal return, this gain may be eroded over time if the expenditure obligations associated with the new resident cohort grow faster than their income tax contributions. In Germany, the most expenditure-elastic services — long-term elderly care and child protection — are primarily financed at the federal-state or county level (see 3), limiting the direct municipal exposure. However, municipalities bear residual co-financing obligations and face rising political pressure as ageing populations increase demand for locally provided services. A municipality that designates housing predominantly attractive to older in-migrants may therefore find that the revenue gains from the income tax base are partially offset by growing expenditure claims within a decade of development. Our payback framework does not capture this dynamic and should be interpreted accordingly.

Furthermore, a holistic view of land development should consider environmental aspects. Within our sample period, approximately 500,000 m^2 of land previously used for agriculture or left in its natural state are converted daily in German municipalities for urban sprawl (Federal and State Statistical Offices, 2025c). Agricultural land and uncultivated areas are scarce resources that must be managed

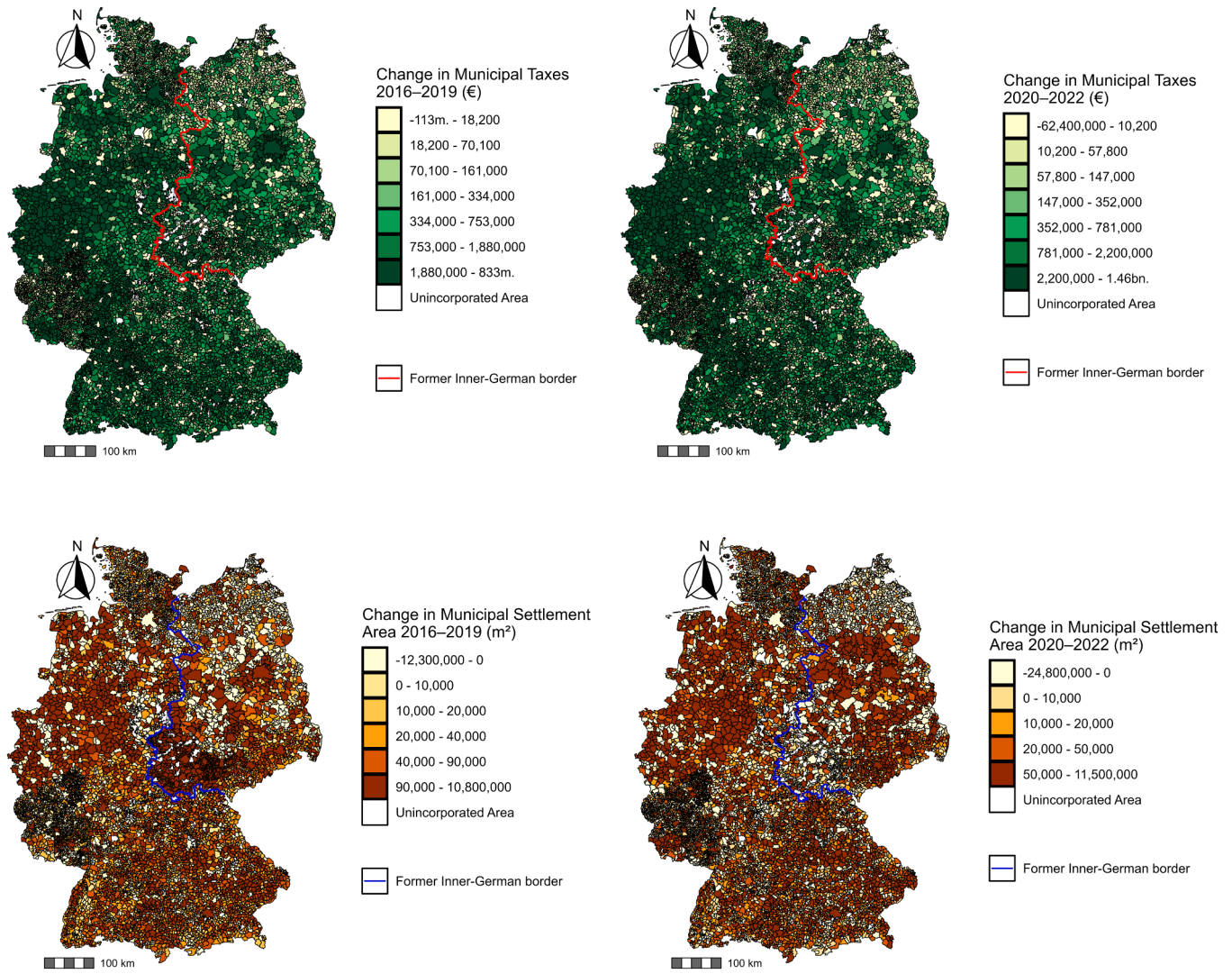

Fig. 7. Sub-Sampling of Total Municipal Tax Revenues and Buil-Up Settlement Area. This figure displays the change in total municipal tax revenues in € between 2016 and 2019 on the left, and the change in total municipal tax revenues in € between 2020 and 2022 on the right in the top row. In the bottom row, the change in municipal settlement area in m^2 is depicted between 2016 and 2019 on the left side and between 2022 and 2022 on the right side. Darker color refers to higher tax revenue increases and higher increases in settlement area, respectively. The course of the former inner-German border is shown in red color in the top row and in blue color in the bottom row. Data sources: Federal and State Statistical Offices (2025a) & Federal and State Statistical Offices (2025c).

sustainably to preserve biodiversity. Initiatives such as the tradable planning permits (TPP) by Henger and Bizer (2010), described in 3, demonstrate cross-regional steering elements for sustainable land development. Another approach by Osterburg et al. (2023) is based on maximizing synergy effects between different types of land-use to minimize the sealing of previously unsealed areas.

It is also worth noting that our independent variable in the income tax revenue regression framework — change in living space (m^2) — captures two conceptually distinct mechanisms. At the extensive margin, additional living space accommodates more residents, expanding the income tax base proportionally to the income distribution of new arrivals. At the intensive margin, larger housing units — reflecting rising space standards and the preferences of wealthier or older households — tend to attract higher-income residents who contribute disproportionately to income tax revenues under Germany's progressive rate schedule, while making comparatively fewer demands on locally financed services. This second channel may itself be a deliberate municipal strategy is well-founded: zoning for larger single-family housing in suburban or peri-urban locations can selectively attract high-income, low-service-demand households. Our finding that the fiscal return to living space expansion is significantly larger in high-income municipalities (Table 4, columns 6–9) is consistent with this income-sorting mechanism. Disentangling the two margins empirically would require parcel-level data on housing type and occupant income not currently available at the national scale; we identify this as a direction for future research.

8. Conclusion

This study provides a comprehensive empirical analysis of the fiscal impacts of residential and settlement land development across German municipalities. We apply spatial regression techniques on a cross-sectional dataset of German municipalities, covering changes in the time period 2016–2022. The findings of our research are threefold.

First, there is a positive and significant relationship between the expansion of living space and municipal income tax revenues, even after controlling for various economic and demographic factors. This effect averages at around €47 per m^2 of additional living space. The significant positive effect remains consistent in various robustness tests. However, the coefficient size changes when spatial effects are used for moderation,

or subsamples are applied. The effect of living space expansion on municipal income tax revenues is, for instance, greater in western Germany than in eastern Germany. Tax revenues after 2020 are also slightly higher than in the period from 2016 to 2019. To enable a comparison of the findings on the effect of living space designation on municipal income tax revenues, a further model estimates the effect of expanding a municipality's total settlement area on its total tax revenues. This model expands the income tax estimate by including municipal tax revenues resulting from taxes on businesses, sales and properties. Instead of living space, the adapted settlement area includes land areas used for residential and commercial purposes as well as infrastructure areas. The average effect of designating one square meter of settlement area on the municipality's total tax revenue is estimated at around €12 per m^2. Given that a municipality can rarely designate living space without creating the associated settlement areas, in particular regarding infrastructure, both effects should be examined together.

Second, spatial connections are identified, indicating that municipal tax revenues and land development of neighboring municipalities are not independent of each other. Given the significant spatial effects observed, it is evident that municipalities do not exist in isolation. Local governments should collaborate across municipal borders, to optimize land-use and infrastructure projects. The interconnectedness of municipalities also reinforces the potential efficacy of mechanisms that can promote a more coordinated and optimal land-use approach across regions, such as tradeable planning permits or inter-municipal land-use concepts. However, spatial relationships may also exist within municipalities that could not be modeled in this analysis due to a lack of data. Neighboring city districts may, for instance, be interdependent, or effects of urban sprawl may alter the cityscape, and, thereby, a municipality's tax revenue.

Third, the results obtained provide evidence on average tax revenues of municipalities resulting from the designation of living space or settlement areas. Conducted tests for spatial heterogeneity have already shown that the results can vary significantly depending on their location. For instance, tax revenues resulting from land development in urban areas and in areas with higher incomes and higher prices for building land tend to be higher. Other factors, such as subsidies, surcharges, compensatory measures, local cost structures, environmental protection impacts, and infrastructure requirements may influence individual decisions on the designation of living space or settlement areas. Even though this study provides small-scale analysis at the municipal level, the decision to designate residential land will remain a case-by-case decision at the local level.

CRediT authorship contribution statement

Albert Erasmus Grafe: Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization. **Julius Leonhard Range:** Writing – original draft, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix

Table A1
Descriptive Statistics

	Obs.	Mean	Std. dev.	25%	50%	75%	Income tax estimation	Total tax estimation
Dependent variables								
Municipal income tax revenue in €	10,744	891,451	8615,000	70,603	221,426	658,546	√	×
Total municipal tax revenue in €	10,744	3389,293	33,877,530	120,440	467,248	1776,900	×	√
Municipal control variables								
Built-up living space in m^2	10,744	16,618	97,354	1200	4300	14,000	√	×
Built-up settlement area in m^2	10,744	101,326	708,884	10,000	40,000	120,000	×	√
Population density in inhabitants per km^2	10,744	3.704	14.464	−1.090	1.198	5.674	√	√
Unemployment ratio in %-points	10,744	−0.446	0.009	−0.780	−0.300	0.014	√	√
Share of houses out of all buildings in %-points	10,744	−0.062	0.554	−0.237	0.000	0.117	√	√
Business tax multiplier in %-points	10,744	8.976	19.442	0.000	0.000	15.000	×	√
Property tax (A) multiplier in %-points	10,744	16.710	38.176	0.000	0.000	24.000	×	√
Property tax (B) multiplier in %-points	10,744	21.150	40.608	0.000	0.000	31.000	×	√
County-level control variables								
Share of employees in the manufacturing industry in %-points	400	−0.332	0.013	−0.994	−0.243	0.385	√	√
Share of employees in the construction industry in %-points	400	0.237	0.005	−0.039	0.250	0.530	√	√
Share of employees in the trade and tourism industry in %-points	400	−0.503	0.011	−1.065	−0.521	0.056	√	√
Share of employees in the financial industry in %-points	400	−0.103	0.009	−0.663	−0.142	0.482	√	√

(*continued on next page*)

Table A1 (*continued*)

	Obs.	Mean	Std. dev.	25%	50%	75%	Income tax estimation	Total tax estimation
Share of employees in the service industry in %-points	400	1.080	0.010	0.419	1.116	1.607	√	√
Share of employees in the agricultural industry in %-points	400	−0.424	0.004	−0.577	−0.340	−0.176	√	√
Debt burden ratio in %-points	400	−0.355	0.230	−0.498	−0.354	−0.221	√	√
Share of old population in %-points	400	4.064	2.300	2.600	3.300	5.200	√	√
Disposable household income per inhabitant in €	400	4481	798.30	4031	4524	4938	√	√
GDP per capita in €	400	6915	3061	5117	6648	8054	√	√
Transferred building land in 1000 m²	400	2721	1816	1449	2382	3625	√	√
Price for building land in € / m²	400	55.37	110.53	9.16	31.42	63.66	√	√
Municipal debt per inhabitant in €	400	−139.52	415.28	−346.00	−100.00	87.75	√	√
Taxable turnover in 1000 €	400	3582,643	6634,018	1045,437	2108,030	3838,552	×	√
Taxable turnover: primary sector in %-points	400	0.652	1.015	0.129	0.449	1.065	×	√
Taxable turnover: industry sector in %-points	400	−2.892	8.645	−4.505	−1.695	0.883	×	√
Taxable turnover: public sector in %-points	400	1.236	3.817	0.085	0.814	2.046	×	√
Taxable turnover: real estate sector in %-points	400	0.531	2.232	−0.494	0.520	1.462	×	√
Taxable turnover: trade sector in %-points	400	−0.516	5.982	−3.254	−0.700	1.758	×	√
Taxable turnover: service sector in %-points	400	−0.444	2.670	−1.707	−0.400	0.781	×	√
Taxable turnover: financial sector in %-points	400	0.483	1.856	−0.054	0.104	0.552	×	√
Instrument								
Vegetation areas and green spaces 2016 in m²	10,744	26,991,146	32,779,750	6970,000	16,070,000	34,325,000	√	√

This table presents summary statistics for all variables of our data set. Monetary variables are in nominal prices and in euro. All variables, except for the instrument, are reported as changes between 2022 and 2016.

Table A2
Moran's I Test Statistics for Municipal Income Tax

Sample	Spatial weights matrix	Moran's I test statistic
2016–2022 Full sample	Inverse distance spatial weights matrix	0.013***
2016–2022 Full sample	First-order spatial weights matrix (Queen method)	0.041***
2016–2019 Full sample	Inverse distance spatial weights matrix	0.017***
2020–2022 Full sample	Inverse distance spatial weights matrix	0.016***
2016–2022 West Germany	Inverse distance spatial weights matrix	0.029***
2016–2019 West Germany	Inverse distance spatial weights matrix	0.027***
2020–2022 West Germany	Inverse distance spatial weights matrix	0.030***
2016–2022 East Germany	Inverse distance spatial weights matrix	0.004***
2016–2019 East Germany	Inverse distance spatial weights matrix	0.006***
2020–2022 East Germany	Inverse distance spatial weights matrix	0.005***

This table presents the results of Moran's I test, developed by Moran (1950), applied on the municipal income tax revenues difference for various samples. Distance-based neighborhood matrices as well as a first-order queen neighborhood matrices were applied. For detailed information on the neighborhood set up, see Section 5.1. Significance levels are indicated by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$.

Table A3
Moran's I Test Statistics for Total Municipal Taxes

Sample	Spatial weights matrix	Moran's I test statistic
2016–2022 Observation period	Inverse distance spatial weights matrix	0.016***
2016–2022 Observation period	First-order spatial weights matrix (Queen method)	0.052***
2016–2019 Observation period	Inverse distance spatial weights matrix	0.023***
2020–2022 Observation period	Inverse distance spatial weights matrix	0.011***
2016–2022 West Germany	Inverse distance spatial weights matrix	0.023***
2016–2019 West Germany	Inverse distance spatial weights matrix	0.030***
2020–2022 West Germany	Inverse distance spatial weights matrix	0.014***
2016–2022 East Germany	Inverse distance spatial weights matrix	0.002***
2016–2019 East Germany	Inverse distance spatial weights matrix	0.008***
2020–2022 East Germany	Inverse distance spatial weights matrix	0.001**

This table presents the results of Moran's I test, developed by Moran (1950), applied on the total municipal taxes revenues difference for various samples. Distance-based neighborhood matrices as well as a first-order queen neighborhood matrices were applied. For detailed information on the neighborhood set up, see Section 5.1. Significance levels are indicated by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$.

Table A4
Effects of Residential Land Development on Municipal Income Tax

	(1) SAR	(2) SAR	(3) IV	(4) IV
Built-up living space in m²	61.949***	61.671***	52.078***	60.180***
	(4.949)	(5.024)	(2.752)	(3.389)
Population density in inhabitants per km²		2620		3916
		(5500)		(4333)
Unemployment ratio in %-points		−506,180		−697,700
		(1876,200)		(1749,400)
Share of houses out of all buildings in %-points		−376,120***		−356,390***
		(117,840)		(113,420)
Share of employees in the manufacturing industry in %-points		924,980		1090,900
		(4053,600)		(3974,100)
Share of employees in the construction industry in %-points		−8449,600*		−8483,600*
		(4451,700)		(4418,800)
Share of employees in the trade and tourism industry in %-points		4810,700		5034,100
		(4257,500)		(4258,600)
Share of employees in the financial industry in %-points		1333,900		1010,300
		(4162,200)		(4062,300)
Share of employees in the service industry in %-points		1576,400		1847,500
		(4001,100)		(3875,100)
Share of employees in the agricultural industry in %-points		16,456,000***		16,640,000***
		(4262,000)		(4123,600)
Debt burden ratio in %-points		−94,759		−90,447
		(120,540)		(125,100)
Share of old population in %-points		26,820		21,243
		(37,702)		(34,330)
Disposable household income per inhabitant in €		−40.361		−49.206**
		(27.386)		(24.210)
GDP per capita in €		−3.578		−2.111
		(8.950)		(8.468)
Transferred building land in 1000 m²		−49.595**		−51.517**
		(24.412)		(24.405)
Price for building land in € / m²		740.220		869.830
		(584.690)		(762.310)
Municipal debt per inhabitant in €		54.041		61.026
		(52.764)		(49.930)
Spatial parameter (ρ)	−0.127***	−0.127***	−0.051*	−0.116***
	(0.048)	(0.0049)	(0.027)	(0.044)
Municipal-level controls	No	Yes	No	Yes
County-level controls	No	Yes	No	Yes
State fixed effects	Yes	Yes	Yes	Yes
Observations	10,744	10,744	10,744	10,744
Sigma	1322,912	1299,901	1422,495	1301,775
AIC	333,389	333,028	334,949	333,059
BIC	333,520	333,275	335,080	333,306
First stage results				
Vegetation areas and green spaces 2016 in m²			0.0004***	0.0004***
			(0.0001)	(0.0001)
F-statistic			472.765***	586.537***

This table presents the results of spatial autoregressive regressions analyzing the impact of living space development on changes in municipal income tax revenues. The dependent variable in models (1) to (4) is the change in municipal income tax revenue. All variables, except for the instrument, are shown as differences between 2022 and 2016. Models (3) and (4) include an instrumental variable, which is not included in the second stage estimation of the models. Heteroskedasticity robust standard errors are in parentheses. Significance levels are indicated by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$.

Table A5
Effects of Settlement Land Development on Total Municipal Taxes

	(5) SAR	(6) SAR	(7) IV	(8) IV
Built-up settlement area in m²	1.909**	2.057***	9.796***	14.146***
	(0.945)	(0.747)	(2.261)	(3.266)
Population density in inhabitants per km²		247,650***		294,300***
		(52,867)		(58,115)
Unemployment ratio in %-points		−2531,600		8129,300
		(14,693,000)		(15,693,000)
Share of houses out of all buildings in %-points		1799,200***		−53,472
		(503,400)		(553,380)
Business tax multiplier in %-points		−65,444		−54,466
		(48,833)		(47,952)
Property tax (A) multiplier in %-points		9005		8142
		(12,252)		(12,425)

(*continued on next page*)

Table A5 (*continued*)

	(5) SAR	(6) SAR	(7) IV	(8) IV
Property tax (B) multiplier in %-points		−7133		−8109
		(8185)		(8553)
Share of employees in the manufacturing industry in %-points		−19,681,000		168,020,000
		(151,590,000)		(149,870,000)
Share of employees in the construction industry in %-points		−26,719,000		235,990,000**
		(100,009,000)		(117,570,000)
Share of employees in the trade and tourism industry in %-points		21,553,000		208,140,000
		(133,530,000)		(139,570,000)
Share of employees in the financial industry in %-points		−54,784,000		138,300,000
		(136,070,000)		(134,420,000)
Share of employees in the service industry in %-points		16,940,000		206,750,000*
		(986,880,000)		(106,510,000)
Share of employees in the agricultural industry in %-points		−185,280,000		71,486,000
		(121,180,000)		(121,140,000)
Debt burden ratio in %-points		1024,300		1410,000
		(1961,300)		(1996,700)
Share of old population in %-points		−902,690*		−396,290
		(486,400)		(471,020)
Disposable household income per inhabitant in €		−1324***		−973.430**
		(45.160)		(442.600)
GDP per capita in €		365.030		344.010
		(833,030)		(835.010)
Transferred building land in 1000 m²		−2743***		−2941***
		(546.780)		(579.780)
Price for building land in € / m²		10,559		8749
		(10,928)		(10,494)
Municipal debt per inhabitant in €		−2596*		−3190**
		(1467)		(1596)
Taxable turnover in 1000 €		1.816***		1.819***
		(0.585)		(0.568)
Taxable turnover: primary sector in %-points		217,060		−88,381
		(224,790)		(209,660)
Taxable turnover: industry sector in %-points		51,664		45,382
		(36,221)		(37,208)
Taxable turnover: public sector in %-points		291,910**		277,520**
		(119,250)		(119,300)
Taxable turnover: real estate sector in %-points		661,500**		674,830**
		(265,050)		(271,570)
Taxable turnover: trade sector in %-points		21,389		22,397
		(81,344)		(82,112)
Taxable turnover: service sector in %-points		255,070		179,080
		(161,800)		(154,210)
Taxable turnover: financial sector in %-points		840,320		840,190
		(547,960)		(542,010)
Spatial parameter (ρ)	0.611***	−0.233	0.481***	0.275
	(0.142)	(0.206)	(0.134)	(0.205)
Municipal-level controls	No	Yes	No	Yes
County-level controls	No	Yes	No	Yes
State fixed effects	Yes	Yes	Yes	Yes
Observations	10,744	10,744	10,744	10,744
Sigma	22,907,127	19,566,642	23,557,175	21,228,697
AIC	394,664	391,304	395,266	393,056
BIC	394,796	391,632	395,397	393,984
First stage results				
Vegetation areas and green spaces 2016 in m²			0.0030***	0.0028***
			(0.0005)	(0.0005)
F-statistic			158.504***	143.357***

This table presents the results of spatial autoregressive regressions analyzing the impact of settlement land development on changes in total municipal tax revenues. The dependent variable in models (5) to (8) is the change in total municipal tax revenues. All variables, except for the instrument, are shown as differences between 2022 and 2016. Models (7) and (8) include an instrumental variable, which is not included in the second stage estimation of the models. Heteroskedasticity robust standard errors are in parentheses. Significance levels are indicated by *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$.

Data availability

The authors do not have permission to share data.

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