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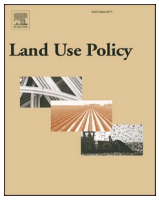

Socio-economic, political and fiscal drivers of unsustainable local land use decisions

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ABSTRACT

For decades, various Austrian spatial planning strategies have emphasized the need to curb land consumption and land sealing. The growth paradigm in concrete land use planning is prevalent to this day: land consumption is still closely coupled to income (GDP) growth, while existing and newly introduced policy instruments were basically ineffective in curbing land consumption. Local decision-makers often expect to improve the fiscal position (municipal budgets) by a growth of residents as well as of businesses, as both increase revenues transferred to municipal budgets within the Austrian fiscal federalism framework (revenue sharing system/ Finanzausgleich). This paper investigates the drivers and determinants of unsustainable land use (e.g., increased land take and land sealing for buildings and infrastructure that reduce soil ecosystem services) in Austria, and, in particular, the economic (fiscal) incentives for municipal decision-makers to adhere to the growth paradigm in Austrian spatial development. Based on a conceptual politico-economic model of land use decisions in Austria that takes into account various market and planning failures (e.g., externalities, fiscal illusion, behavioral anomalies, political determinants, moral hazard), the paper assesses the importance of the different drivers of land use decisions. Several key socio-economic and structural variables (e.g., population, income, demography) proved to be significant in explaining the continuous growth trend in land consumption. In addition, there is substantial spatial correlation in municipal land use decisions. The paper draws several conclusions on innovative policy approaches to escape the growth paradigm in spatial planning, in particular, new fiscal instruments to curb unsustainable land use patterns, which target both public (municipal) decisions makers as well as private land owners.

1. Introduction and background

Compared to other EU countries, Austria's land consumption (land take) and land sealing are above average. Land sealed for built areas has increased by about 32 % in Austria between 1996 and 2006 (EU average: about 9 %). The average Austrian citizen 'consumes' at total of about 600 m^2 of land, while the EU average is roughly 400 m^2 (cf. Getzner and Kadi, 2020; Prokop et al., 2011; UBA, 2017; Schiavina et al., 2022). This development in Austria has been attributed, among other things, to an underlying strong growth paradigm in the Austrian spatial planning system (Müller et al., 2024; cf. Durrant et al., 2023).

In this paper, we use the term 'land consumption'[2] as a synonym for 'land take' to refer to land that is converted into areas for buildings and infrastructure (see the report of the Austrian Panel on Climate Change (APCC) in Jandl et al., 2024), including not only the sealed surface but also the surrounding areas such as artificial surfaces (e.g. car parks) and green areas (e.g. parks, artificial gardens) (Marquard et al., 2020; Prokop et al., 2011). Thus, land consumption (land take) includes all areas that were originally natural, agricultural or forest land and therefore lack important soil functions with significantly reduced ecosystem services. According to the European Environment Agency (2022), land consumption also includes soil that is not necessarily sealed by impermeable surfaces. The latest APCC Special Report (Jandl et al., 2024) strongly suggests that both land use and soil sealing in Austria are

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[2] Of course, land cannot be 'consumed' in the strict sense, but we use the shorthand term 'land consumption' or 'land take' to indicate that important original soil functions have been reduced or lost.

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unsustainable, especially in view of the significant reduction of soil functions (ecosystem services) and the drivers and consequences for biodiversity loss (see also Schirpke et al., 2023).

This paper also looks at different types of land use, based on zoning, in particular for residential and commercial purposes (building) and infrastructure (transport). 'Land sealing' (soil sealing, sealed surfaces) is included in total land consumption and refers only to areas that have lost all ecological soil functions and are sealed with impermeable surfaces (e.g. Burghardt, 2006; Peroni et al., 2022). Of course, operational definitions, data and statistics are not so clear-cut, as will be discussed in the empirical sections below. However, this paper closely follows the definitions of land consumption (land take) and sealed land (land sealing) as outlined here.

The 'growth paradigm' in spatial planning can be described as the implicit or explicit expansive spatial development policies and practices that still prevail despite the many official documents and strategies aimed at a resilient and sustainable land use planning (Savini et al., 2022; Wächter, 2013; Davoudi, 2012). More than 20 years ago, the Austrian Sustainability Strategy (STRAT) was drafted, which included a quantitative target to reduce land consumption from more than 12 ha a day at that time to less than 2.5 ha. This general strategy to curb land consumption was recently renewed in the Austrian "Strategy for the conservation of Soil and Land" [Bodenstrategie] (ÖROK, 2023). At around 13 ha a day, Austrian land consumption is unsustainable and one of the highest in the EU (cf. Bröthaler et al., 2023; Schiavina et al., 2022). The recently passed strategy has omitted any quantitative goals of reducing land take and soil sealing, while it has introduced a standardized statistical measurement of land use and a new monitoring system.

In current politics, the 'growth paradigm' of the Austrian system of spatial planning is apparent both in recent statements by policy-makers, as well as in the central spatial planning strategies. On the one hand, in a recent debate on limiting additional land take, the Austrian Finance Minister said that this would put "a brake on economic growth" (Die Presse, 2024; translation by the authors). On the other hand, the Austrian Spatial Planning Strategy (ÖREK2030; see ÖROK, 2021) is ambiguous about the links between land take, land sealing and economic growth. While one of the basic strategic statements reads like a (soft) critique of growth – "One of the most important tasks of the system of spatial planning is the timely identification of growth limitations" (ÖROK, 2021, p. 14; translation by the authors) –, various other statements in the context of urban and economic development as well as infrastructure planning resemble the assumption that expansive land use is a prerequisite, or at least goes hand in hand, with economic growth (Müller et al., 2024).

Of course, policy instruments such as land-use planning, zoning laws, local and regional development plans, infrastructure planning (local/regional/federal), and nature conservation frameworks, have been more refined over the years. However, as Getzner and Kadi (2020) show in their empirical study, land consumption in Austria is still coupled to income (GDP) growth, while new policy instruments over time (such as diverse land management instruments, e.g. stricter building codes and zoning plans; regulations regarding second homes) have been basically ineffective in curbing land sealing and land consumption.

Overall, despite both changes in strategies and policy goals, as well as changes in the governance frameworks including policy instruments, local decision-makers central to land use decisions – mayors and municipal councils – are still stuck in this growth paradigm, rendering the above-mentioned strategies ineffective: Residential and commercial areas continue to be developed, resulting in high and unsustainable sealing of land that seizes to provide fundamental ecosystem services (e.g. provision of food, groundwater regeneration, carbon storage, nutrient cycling; cf. Schirpke et al., 2023).

The basic reason for unsustainable land consumption seems to be the belief that growth – growth of the population of the municipality, of infrastructure, of resource use – contributes to a higher living standard, and to a better quality of life. In particular, local decision-makers expect an improvement in the fiscal position (municipal budgets) from growth in the number of residents and businesses, since both increase the revenues from own taxes and transfers to municipal budgets within the Austrian fiscal federalism framework (revenue sharing system/Finanzausgleich) (Buettner, 2023). However, the growth of residents and businesses also increases the need for municipal spending in order to provide the necessary technical and social infrastructure (e.g. utilities, roads, schools, care facilities) (Mahtta et al., 2022; Neuhuber et al., 2025).

Against this background, this paper explores the drivers and determinants of unsustainable land consumption and sealing of surfaces in Austria, and in particular deals with the economic (fiscal) incentives for municipal decision-makers to adhere to the growth paradigm in Austrian spatial development. Thus, this paper refers to a politico-economic model of local land use and zoning decision-making, and tests for various political variables. The methodological approach is quantitative and draws on the best available data on land consumption and land sealing. In addition, it also explores the spatial correlations within the Austrian planning system in a spatial econometric framework.

Based on the discussion below, and the literature briefly reviewed in the following section, this paper focuses on:

- Structural and socio-economic determinants of local land use and zoning decisions in Austria;
- the importance of politico-economic and fiscal variables in zoning decisions;
- the spatial correlation of zoning decisions with decisions made in the surrounding region.

The paper thus contributes to the literature on land use policies and decision making by linking socio-economic, political and spatial determinants of land use decisions with the fiscal implications and incentives faced by local decision makers. To the best of our knowledge, it is the first empirical paper that specifically accounts for this wide variety of determining influences on local land use policies. Furthermore, it emphasizes the various market and planning failures, in particular, in regard to behavioral and information imperfections.

The paper is organized as follows: A brief literature review on selected aspects of the politico-economic determinants of land use and zoning decisions is provided in Section 2. In Section 3, the conceptual politico-economic model is described, while Section 4 presents condensed descriptive information on municipal land consumption, land sealing and zoning decisions in Austria. Section 5 presents the methodology and the results of econometric estimations including the spatial dependence of land consumption and land sealing. Finally, a summary and policy conclusions are presented in Section 6.

2. Determinants of decisions on zoning and land use plans: a brief literature review

As land use and zoning decisions are usually made by public (municipal, regional) authorities, they are based on a variety of constitutional and statutory legal frameworks. Such decisions often involve economic, social and ecological considerations, while at least some part of the decision is made in a specific political environment, i.e. by mayors, town councils or committees. For Austria, Getzner and Kadi (2020) have recently concluded that – among other socio-economic factors – the income levels of local households had a significant influence on the amount of land devoted to residential use. An increase in

income levels – ceteris paribus – contributes significantly to land consumption and land sealing.[3] Interestingly, the authors found that major new policy frameworks (e.g., new instruments of land policies) do not (yet) have a significant influence on reducing land consumption. A conclusion of this recent study is that the policy frameworks and politico-economic influences seem to be the main drivers of land use policies.

In general, the available literature finds that there is a wide variety of determining factors of land use, zoning, and, more specifically, housing demand. In general, economic growth and land use change are often closely correlated (e.g., Colsaet et al., 2018). Most studies assume that income growth drives expansive land use policies; only a few studies assume that expansive land consumption is an important driver of economic growth, given the high density of existing infrastructure and residential and commercial land in industrialized countries. In their studies of Italian spatial development, Bimonte and Stabile (2017a), (2017b) find that income is a major determinant of land consumption. Other recent studies on the driving force of income for expansive land-consuming activities (e.g., housing, size of apartments) include Caldera and Johansson (2013) and Green et al. (2006).

In parallel with economic development, demographic and social factors are key to changing preferences and demand both in terms of land consumption and the housing sector (Haase et al., 2008; Salvati et al., 2018). Furthermore, the specific local contexts, together with historical and cultural factors, are formative for local land use policies (Salvati et al., 2018; Masini et al., 2019).

Research on the political determinants of sustainability policies, such as land use decisions that take into account ecological limits (planetary boundaries), has revealed that these factors can be crucial in explaining certain decisions in regard to sustainability transformations. In particular, vested interests, lobbying, rent-seeking, and various other informal channels of influence can be major impediments to transition policies: "Modern political economy also breaks the 'taboo' of viewing and modeling (local) government as purely benevolent and critically explores government failures" (Fragkias and Boone, 2016, p. 63). For instance, Verburg et al. (2004) find that land use change in the Netherlands is driven not only by the geography and by biophysical characteristics, but also by spatial policies and neighborhood interactions. Local contexts are particularly important in regard to agency related to land use and climate governance. Decisions are framed differently, with the political environment as an important factor alongside socio-economics and demographics (Haupt et al., 2024).

The spatial dependency of land-use patterns has also been emphasized by Chakir and Parent (2009) in their study on French municipal land use decisions at the parcel level (see also Chakir and Le Gallo, 2021; for Italy: Punzo et al., 2022). However, much of the variance in many empirical studies is due to unobserved variables. The recent study by Schiavina et al. (2022) provides evidence on the spatial determinants of land use decisions: the efficiency of land use has improved in urban areas, while it has deteriorated in rural areas with a lower population density.

The political economy of land use decisions may also be a reason for the ineffectiveness of some land use planning instruments. Regulations often do not appear to significantly curb land consumption and land sealing (e.g., Gennaio et al., 2009; Siedentop et al., 2016; Weitz and Moore, 1998).

[3] Alternatively, wealthier residents may try to close the municipality to newcomers. While Getzner and Kadi (2020) did not find such mechanism, we argue in this paper that policymakers may respond to the partial interests of wealthy households. However, income may be a more important driver of land consumption.

3. A conceptual model of the determinants of municipal land use decisions in the Austrian planning system

Municipal land use decisions are embedded in institutional, legal, economic, social and political frameworks, recognizing the fact that no single determinant of land use decisions prevails in Austrian spatial development policy (for Austria, e.g., Svanda and Zech, 2023). Based on the legal and institutional frameworks as well as on the (empirical) literature on land use decisions, this paper develops a politico-economic model that identifies the main drivers of unsustainable land use policies and thus of the local growth paradigms in spatial development. Fig. 1 presents a sketch of a broad conceptual model that describes both the institutional and legal frameworks as well as the politico-economic environment of land use decisions.

At the center of the model are local decision makers (mayors and municipal councils) who seek re-election and maximize their popularity. Expanding the availability of infrastructures and providing more public services is widely considered popular, and can be gained with population growth – this is certainly part of the growth paradigm in the Austrian spatial planning system (Müller et al., 2024). Furthermore, decision makers may be influenced by special interests, such as property owners and businesses.

As Austria is a federal state consisting of three levels of government (national, provincial/regional, local), the coordination and cooperation between these levels is crucial for achieving a wide range of policy goals, especially in the areas of climate and biodiversity protection (e.g. Getzner and Bröthaler, 2019). At the federal (national) level, the Austrian constitution both defines the legal competencies of the different levels of government and provides the basis for the fiscal federalism system (e.g., the legal authority to raise taxes, the definition of the cost bearing of policies, and the revenue sharing and fiscal equalization system). According to the Austrian Constitution, nature conservation and spatial development including land use decisions are the legal responsibility of the provincial governments; the actual land use (zoning) decisions are made by the local level of government (municipalities). The provincial government is responsible for enacting the planning laws and supervising all local decisions.

As briefly discussed in Section 2, political leaders (e.g., members of municipal councils, mayors) may want to be re-elected. The popularity of candidates is a determining factor for re-election. Thus, local decision-makers may face at least two types of pressures. On the one hand, voters may appreciate the outcomes of spatial development and land use policies, and they may also be mobile in their choice of residence (cf. Calabrese et al., 2007, for a theoretical framework). Improvements and expansions of local infrastructures as a consequence of economic growth (population, businesses) can be rewarded with votes for incumbent decision-makers. Moreover, local decisions are particularly susceptible to the vested interests of local businesses and landowners, who may enjoy substantial increases in the value of their property when undeveloped land (e.g. agricultural land) is converted into building land.

Such policies, which are considered unsustainable (Schirpke et al., 2023), are feasible, especially if the full costs can be externalized. The expansion of unsustainable land use thus may appear rational from the perspective of municipal decision-makers. However, from the viewpoint of overall economic efficiency, several planning failures facilitate current unsustainable land use policies. These include:

- Externalities of unsustainable land use, such as the loss of biodiversity and soil functions: Expansive land take and sealing of surfaces lead to the loss of ecological functions of the soil, the costs of which can be externalized to the surrounding regions;
- Effects on GHG emissions owing to a dispersed spatial development (urban sprawl);
- Fiscal illusion of policy-makers and citizens who expect an improvement of the fiscal position of their municipalities (e.g., Mancini and Tommasino, 2023), and moral hazard as the fiscal

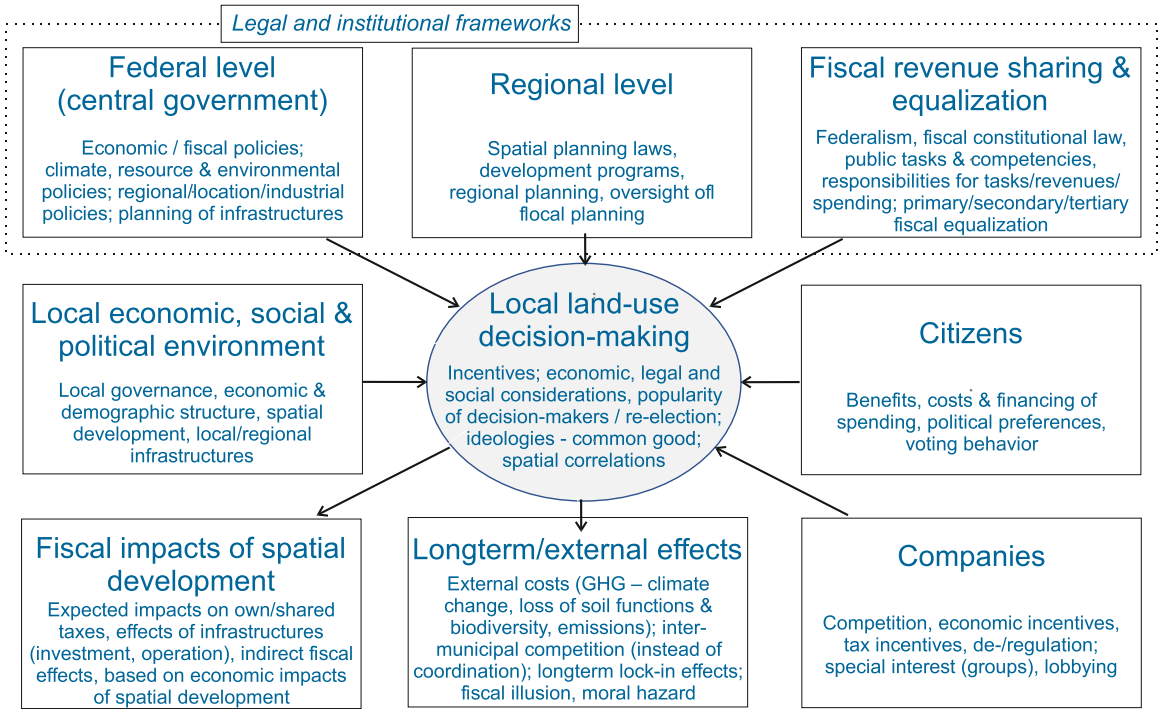

Fig. 1. Conceptual politico-economic model of local land use decision making. Source: own draft.

equalization system can function as an insurance policy (e.g., Oates, 2005);
- Political determinants, such as the ideology of municipal decision-makers, and the influence of vested interests (local businesses);
- Behavioral anomalies, such as the systematic overestimation of the benefits and underestimation of the costs of unsustainable spatial development (cf. Getzner, 2023);
- Spatial correlation of land use decisions based on, for example, yardstick competition, mimicry, location competition, or vulnerability of communities to influential firms (e.g., di Liddo and Giuranno, 2016).

Taking these theoretical politico-economic arguments into account, this paper develops an empirical model of land use decisions. As will be described below in Section 5 in more detail, structural, socio-economic, political and fiscal variables may play an important role in explaining unsustainable spatial developments.

In regard to the expected benefits of land use decisions, one must be aware of the potentially long time lags between a given land use decision and its welfare, economic and fiscal implications. In a rational model of municipal land use policy, decision-makers weigh the benefits and costs to the community (public interest, common good) and to themselves in terms of their chances of re-election.

The time lags can be significant (see Millar et al., 2016, for commercial investment projects). For example, a municipality decides to allocate more land for housing. The decision on land use (zoning), the legal procedures up to its entry into force, and the construction and movement of (new) residents into the municipality can take some time. This paper therefore assumes that decision-makers have specific beliefs and expectations about future revenues and expenditures. As will be shown in Section 5, the time-to-plan lag is built into the estimations of this paper, as the variables do not indicate the point in time when a land use decision was made, but rather the actual use of land (land take), e.g., for construction. Moreover, the equations include an autoregressive term to account for serial correlation and possible time lags.

Before turning to the econometric estimations, Section 4 presents a brief overview of land take in Austria during the last three decades.

4. Land use, land take and land sealing in Austrian municipalities

Before examining selected aspects of the politico-economic model described above, we will briefly present data on land use, land take (land consumption) and land sealing in Austria. Compared to other countries in the European Union, expansive land use planning – apparently following a growth paradigm in spatial planning (cf. Durrant et al., 2023) – is still the main development characteristic of the Austrian planning system. Fig. 2 presents a time series of additional annual land take over the observation period from 1991 to 2023. The increase in total land take for all purposes (e.g., residential, commercial, infrastructure) more than doubled between the beginning of the period (1991) (from about 30–80 km^2 per year) and reached a peak in the years 2008–2011. The financial crisis changed the fundamental conditions for many sectors of the economy including real estate (devaluation of property), construction (reduction in investment) and financial markets (credit crunch, interest rates), leading to a slowdown in zoning and land take for buildings and infrastructure (e.g., Claessens et al., 2010; Kolb, 2010).

In the aftermath of the financial and economic crisis (2008 onwards), additional land take decreased slowly to about 30 km^2 a year. Additional land sealing (sealed surfaces) developed more steadily, reaching 17 km^2 a year in recent years. Classifying and monitoring a particular type of land use, e.g. residential, commercial, or infrastructure, was more challenging 30 years ago, while the recent digitization of compatible databases and assessment methods of land use have made the data more reliable. It should be added that the formal statistical definitions of 'land use' and 'land take' have changed during this period. These time series represent the best available information of a continuous series, adjusted for several structural breaks and short-term fluctuations (data sources and computations by the authors of this paper, using statistical data from the Austrian Statistical Office (STAT) and the Austrian Environmental Protection Agency (UBA)).

In policy papers, land use, land take (consumption) and soil sealing are usually presented in a different metric, i.e., hectares per day. The Austrian sustainability strategy (STRAT, 2002) includes the quantitative

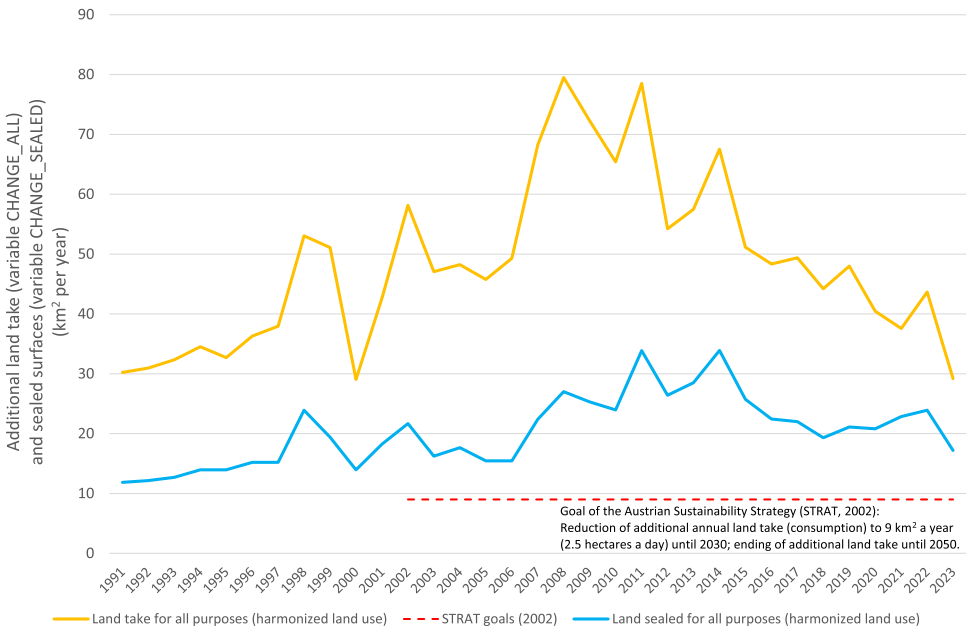

Fig. 2. Change of land take and land sealing in Austria (1991–2023, km² a year). Source: Own draft and calculations of the harmonized land use and land take by the authors' computational model based on UBA (2022), STAT (2023), STRAT (2002).

target of reducing land take to 2.5 ha a day, and other policy papers and strategies at the EU level proposed to eventually end all expansive land take by 2050 (see e.g. European Commission, 2011 and 2021). By 2023, Austria's land take (measured in hectares a day) amounts to about 8 ha a day, which is more than three times the limit set by the sustainability strategy. It is noteworthy that this figure is one of the lowest levels of additional land take that Austria has recorded in a long time.

In comparison to the figures, buildings (both commercial and residential) and transport infrastructure (mostly roads) are the most significant factors of land take (land consumption) (see Fig. 3). Again, on the one hand, this spatial development is well above the thresholds chosen by policymakers themselves, highlighting the partial ineffectiveness of spatial planning instruments (see Getzner and Kadi, 2020). On the other hand, such unsustainable land consumption has significant implications for environmental health and ecosystem services in Austria (Schirpke et al., 2023). Based on these general and descriptive observations, we now turn to the econometric analysis of the determinants of land use, land consumption and sealing in Austria.

5. Determinants of land consumption and sealing in Austria

5.1. Methodological approach, data and hypotheses

In order to explore the research questions discussed in Section 1, we have developed a number of hypotheses based on the politico-economic model presented above.

H1. : Land use decisions (buildings, transport; land consumption, land sealing) depend on the size of the municipality (population) and on population change: Smaller (less populous) municipalities and those with a growing population have a higher per capita growth in land take.

H2. : Socio-economic characteristics determine land use decisions: Municipalities with higher average per capita income, higher average formal education and lower than average unemployment rates have higher land take.

H3. : The scarcity of available (i.e. undeveloped) land is a key determinant of land use decisions: The less land available, the less additional land consumption will occur.

H4. : The influence of municipal budget variables is tested, as it hypothesized that the municipal debt level (administrative financial debt), the free cash flow, municipal revenue shares (financial equalization), receipts from municipal and property taxes (own levies) and from capital transfers (investment grants) from the respective state, have an influence in land use decisions. It is assumed that the expected cash flows provide an incentive to increase land take.

H5. : Land use decisions of municipality A also depend on decisions of neighboring municipality B: Land consumption in municipality A will be higher if the surrounding region also increases land consumption.

In order to test the hypotheses discussed above, a comprehensive data set was developed that includes data on all variables presented in Table 5 (see appendix) for an observation period from 2009 to 2020 (annual data),[4] for all Austrian municipalities (N = 2098). Data sources were mainly the Austrian Statistical Office (STAT) and own data collected during previous research projects (e.g., on the ideology of the mayor's political party, which are not readily available; e.g., Bröthaler et al., 2014). In addition, we used a matrix of distances between Austrian municipalities for the spatial econometric estimations (a detailed description of the data (distance matrices) and the econometric approach is included in a paper by Getzner, 2021, on a spatial econometric estimation of municipal cultural expenditure).

Based on this data set, two models were tested:

1. Fixed effects panel estimation with an AR (auto-regressive) term to account for potential serial correlation in the dependent variable;
2. Fixed effects panel estimation with an AR term and a spatial term ρ (rho) indicating the spatial dependence of the dependent variable

[4] For this period, all data are available in a consistent and complete format. Data before 2009 are subject to structural breaks and changed statistical methods of computation, especially for land use data. Data after 2020 were incomplete at the time of the estimation of the econometric models (see Bröthaler et al., 2023).

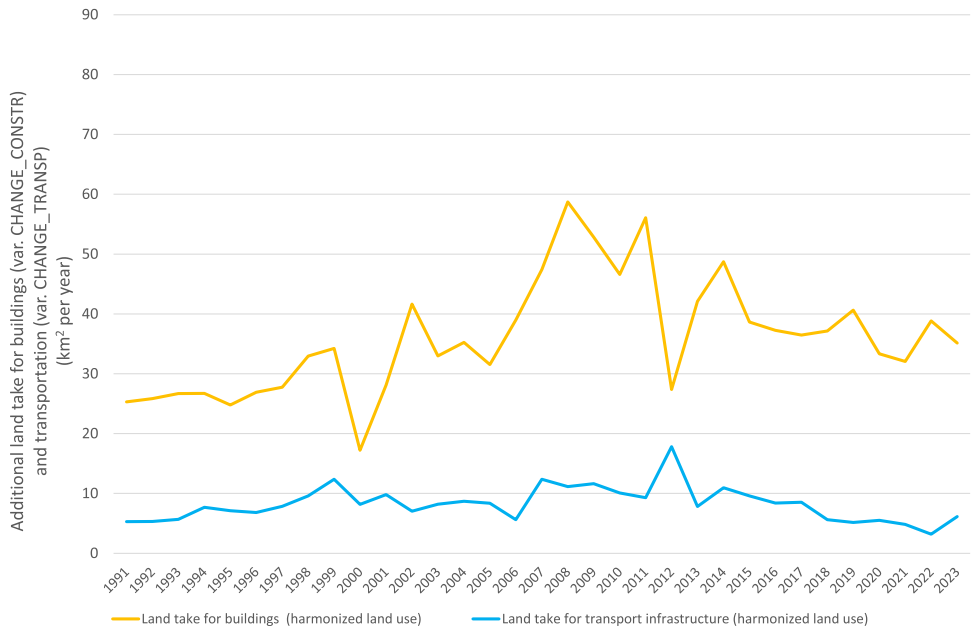

Fig. 3. Change of land take and land sealing in Austria (1991–2023, km² a year) for buildings and transport infrastructure. Source: Own draft and calculations of the harmonized land use and land take by the authors' computational model based on UBA (2022), STAT (2023), STRAT (2002).

with those of other municipalities within a maximum driving distance of 15 minutes.[5]

In both models, business cycles are taken into account through the average income variable (per capita, for each municipality). Annual specific constants (effects) in addition to those already included would lead to over-determination of the estimated equations. The dependent variables are first differences, so the specific constants (cross-section effects) represent constant changes in per capita land use from one year to the next.

The results of both econometric estimation approaches are presented below; the tables include all results in detail, while the main text describes only the most important findings (a detailed description and operationalization of the variables can be found in the Appendix in Table 5).

5.2. *Econometric results: factors of municipal land use decisions*

Based on the theoretical models and methodological approaches outlined above, Table 1 presents the results for the changes in land take for construction and transport infrastructure purposes (per capita). A first important insight is that a main driver of additional land consumption for construction purposes (left part of the table; variable CHANGE_CONSTR) is the size of the municipality: More additional land (per capita) is devoted to construction in smaller (less populated) municipalities (with a decreasing functional form, indicated by the quadratic term). Population growth reduces additional land take for construction, as population density increases and less land is needed per inhabitant. This is also due to the above-average growth of urban areas, which generally have a higher population density. In regard to socio-economics, municipalities with above-average incomes of households and higher levels of formal education – ceteris paribus – also experience more land consumption for construction. Municipalities with scarce land reserves for construction (i.e. a higher proportion of land already used for construction) have limited scope for an expansive spatial development and therefore show lower land consumption for construction and infrastructure.

Contrary to the expectations of many policymakers that municipal (net) revenues would increase with the population or with new businesses, the estimation results infer that there is no significant relationship between land take and municipal (net) revenues. In addition, it is interesting to note that new zoning for construction tends to reduce municipal cash flows and increase municipal debt. This is a key finding, pointing to the substantial costs of providing municipal infrastructure (e.g., technical, social) to new residents and businesses, which do not appear to be offset by additional municipal revenues. The estimations show that additional land consumption not only has no significant impact on increasing municipal revenues, but on the contrary, increases municipal debt levels and reduces free cash flow.

In regard to transport infrastructure (mainly municipal roads, sidewalks, bike lanes; variable CHANGE_TRANSP), there is only a weak influence of the size of the municipality, with smaller (less populated) municipalities allocating more land to transportation (per capita) (see the right part of Table 1). A higher average household income level also leads to more land devoted to transportation. Again, the remaining availability of land (i.e. the already existing stock of transport infrastructure) that can be assigned to transportation is a significant predictor. Finally, the estimation shows that more transport infrastructure is significantly correlated with higher levels of municipal debt, while the other budgetary variables do not exhibit a significant influence on land consumption decisions for transport.

Additional land take (land consumption; per capita) for all purposes (variable CHANGE_ALL), such as residential and commercial buildings, and transport infrastructure, and additional sealed land (i.e. built area with impermeable surfaces, per capita), are also correlated with a number of demographic and socio-economic variables. As Table 2 indicates, land consumption for all purposes is higher in smaller (less populated) municipalities, and is correlated with higher household income and higher levels of formal education, while it is lower as population increases, leading to a higher population density. While the scarcity of land is again a significant predictor, land consumption for all purposes is also positively correlated with municipal debt. Other variables of municipal budgets do not play a significant role.

[5] Many studies have examined the spatial dependence of municipal decisions, and there is generally a wide range of models and approaches is available. For example, Getzner (2021) explored the cultural spending of Austrian municipalities and found significant spatial correlations.

Table 1
Determinants of the changes of land take for construction and transport infrastructure.

	Dependent variables					
	CHANGE_CONSTR			**CHANGE_TRANSP**		
	Coefficient	t-stat.	Prob.	Coefficient	t-stat.	Prob.
Explanatory variables						
Constant	0.874	0.321	0.007 ***	0.416	0.225	0.065 *
POP	−0.295	0.083	0.000 ***	−0.102	0.059	0.084 *
POP^2	0.020	0.006	0.000 ***	0.006	0.004	0.140
POPDev	−1.070	0.027	0.000 ***	−1.019	0.018	0.000 ***
INC	0.043	0.008	0.000 ***	0.020	0.006	0.000 ***
EDU	0.518	0.071	0.000 ***	0.087	0.050	0.078 *
UNEMPL	−0.521	0.081	0.000 ***	−0.002	0.056	0.965
SHARE_CONSTR	−2.112	0.047	0.000 ***			
SHARE_TRANSP				−2.667	0.061	0.000 ***
SHARE_USE						
SHARE_SEALED						
FISC_FREE	−0.007	0.004	0.060 *	0.002	0.003	0.336
FISC_DEBT	0.003	0.001	0.038 **	0.003	0.001	0.006 ***
REV_RS	−0.003	0.013	0.832	−0.002	0.009	0.785
REV_BT	−0.013	0.026	0.608	−0.011	0.018	0.557
REV_PT	−0.075	0.105	0.476	0.014	0.072	0.848
REV_TR	0.002	0.008	0.760	0.006	0.005	0.276
AR(1)	−0.005	0.007	0.486	0.036	0.008	0.000 ***
Adj. R^2	0.174			0.234		
S.E. of regression	0.057			0.039		
Log Likelihood	36,884			46,414		
F-statistics	3.463 ***			4.582 ***		
Durbin-Watson-statistics	2.033			2.070		
Observations	24,694			24,694		
Period	2009–2020 (12)			2009–2020 (12)		
No. of cross-section units (municipalities)	2094			2094		

Panel estimation, fixed effects model; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
Source: Own estimations.

Table 2
Determinants of the changes of land take for all purposes, and land sealed.

	Dependent variables					
	CHANGE_ALL			**CHANGE_SEALED**		
	Coefficient	t-stat.	Prob.	Coefficient	t-stat.	Prob.
Explanatory variables						
Constant	0.218	0.213	0.305	−0.032	0.219	0.883
POP	−0.118	0.055	0.033 **	−0.087	0.057	0.127
POP^2	0.008	0.004	0.046 **	0.007	0.004	0.064 *
POPDev	−1.039	0.018	0.000 ***	−1.028	0.018	0.000 ***
INC	0.045	0.006	0.000 ***	0.043	0.006	0.000 ***
EDU	0.268	0.047	0.000 ***	0.213	0.049	0.000 ***
UNEMPL	−0.262	0.053	0.000 ***	−0.163	0.055	0.003 ***
SHARE_CONSTR						
SHARE_TRANSP						
SHARE_USE	−1.111	0.025	0.000 ***			
SHARE_SEALED				−2.113	0.054	0.000 ***
FISC_FREE	−0.001	0.002	0.587	0.000	0.003	0.989
FISC_DEBT	0.003	0.001	0.005 ***	0.002	0.001	0.016 **
REV_RS	0.005	0.008	0.571	0.015	0.009	0.079 *
REV_BT	−0.021	0.017	0.222	−0.020	0.018	0.263
REV_PT	−0.084	0.069	0.227	−0.141	0.071	0.049 **
REV_TR	0.003	0.005	0.509	0.005	0.005	0.354
AR(1)	0.009	0.008	0.225	0.013	0.008	0.094 *
Adj. R^2	0.241			0.199		
S.E. of regression	0.037			0.038		
Log Likelihood	47,297			46,575		
F-statistics	4.726 ***			3.906 ***		
Durbin-Watson-statistics	2.041			2.099		
Observations	24,694			24,694		
Period	2009–2020 (12)			2009–2020 (12)		
No. of cross-section units (municipalities)	2094			2094		

Panel estimation, fixed effects model; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
Source: Own estimations.

In regard to the area sealed with an impermeable surface (variable CHANGE_SEALED), the estimation exhibits a comparatively lower explanatory power, but still reveals at least some weak influences of budgetary variables. Again, socio-economic and demographic variables are the most significant predictors, while municipal debt is also positively correlated with the share of sealed land. Weak correlations

between the sealed land and budgetary variables can be found with the municipal revenues from the fiscal revenue sharing and equalization system, and from property taxes. In comparison to the influence of the other variables in the estimation, this seems to be only a marginal contribution to explaining land sealing.

Turning to the spatial dependencies in regard to land use decisions, the hypothesis of spatial correlations can clearly be supported by the results of the spatial econometrics estimations.

As the results in Table 3 indicate, the spatial correlation parameter rho (ρ) is highly significant with a coefficient of 0.3 – i.e., a doubling of the additional land allocated to construction in the surrounding municipalities (within a driving distance of 15 minutes), measured in terms of per capita changes from the year *t-1* to *t*, increases the land take for construction by roughly 30 %.

In regard to land consumption for transportation, the spatial correlation is smaller, with a spatial coefficient ρ of about 0.2.

Finally, Table 4 presents the results of the spatial econometric estimations for land take for all purposes, and for sealed land (change, per capita). Again, the spatial correlation between land use decisions of neighboring municipalities is clearly visible in the significantly positive ρ coefficients. While the other coefficients of the explanatory variables remain roughly in the same order of magnitude and significance compared to the non-spatial estimations, variables that take into account municipal revenues (e.g. own taxes, shared taxes) lose their significance in the estimation explaining the area of land sealed. This is a further indication that, contrary to current ad-hoc hypotheses, actual revenues do not exhibit a significant explanatory power for land use decisions.

6. Discussion, summary, and conclusions for urban policies and planning

The politico-economic model presented in this paper is used for a comprehensive empirical study of the importance of the different drivers for land use decisions. Based on data of roughly 2100 Austrian municipalities over the period of 2009–2020, a panel model with fixed effects turned out to provide the best explanatory power for modeling land use decisions, complemented by some spatial econometric estimations testing for the interdependencies between neighboring municipalities.

The econometric estimations exploring potential factors determining municipal land use decisions have uncovered a number of interesting results. In regard to H1 (influence of the size and change in the population of the municipality), the estimations clearly support the hypothesis that in less populated municipalities, per capita land consumption (e.g. for construction, infrastructure) is significantly higher than in urban areas. Population growth reduces per capita land take as density increases.

Socio-economic determinants of land use are also clearly visible (H2): Municipalities with households earning above-average incomes – ceteris paribus – exhibit higher land take per capita, as do municipalities with higher levels of formal education, and lower unemployment rates. However, the scarcity of land – congruent with an already high share of land consumption relative to total land available for development – also significantly determines land use decisions (H3).

Contrary to expectations regarding the influence of municipal revenue variables (H4), variables denoting municipal revenues and budgetary policies do not exhibit a significant influence on land use decisions. Rather, it may well be that some revenues decrease, while spending increases, as we observe higher municipal debt burdens, and lower cash flow levels, of municipalities that pursue expansive land consumption policies.

Finally, it is interesting to note that the spatial correlations between municipalities in a region are significant (H5). The clear and robust significant correlation shows that municipalities pursue zoning policies that are quite similar in the surrounding region. A possible explanation for this spatial correlation could be yardstick competition, as citizens in municipality A observe spatial developments in neighboring communities and demand that their own spatial development should follow the example of the region. Furthermore, municipalities may simply face similar challenges in regard to population development or economic structures, for which similar policies (e.g., expansive land consumption) are applied. However, politico-economic determinants should not be overlooked since the influence of interest groups and the re-election motives of incumbents can be decisive.

In addition to the aforementioned hypotheses, a number of other potentially influential variables were tested (these are also listed in

Table 3
Determinants of the changes of land take for construction and transport infrastructure – spatial econometrics.

	Dependent variables					
	CHANGE_CONSTR			**CHANGE_TRANSP**		
	Coefficient	t-stat.	Prob.	Coefficient	t-stat.	Prob.
Explanatory variables						
POP	−0.173	−2.576	0010 ***	−0.049	−1.037	0.300
POP^2	0.012	2.602	0009 ***	0.004	1.110	0.267
POPDev	−1.065	−44.114	0.010 ***	−1.038	−61.972	0.000 ***
INC	−0.025	−1.996	0046 **	−0.036	−4.089	0.000 ***
EDU	0.161	2.529	0011 **	−0.077	−1.727	0.084 *
UNEMPL	−0.602	−7.261	0.000 ***	−0.053	−0.922	0.357
SHARE_CONSTR	−1.753	−50.123	0.000 ***			
SHARE_TRANSP				−2.250	−53.498	0.000 ***
SHARE_USE						
SHARE_SEALED						
FISC_FREE	−0.003	−1.044	0.297	0.002	0.690	0.490
FISC_DEBT	0.004	3.526	0.000 ***	0.003	3.769	0.000 ***
REV_RS	0.001	0.091	0.928	−0.009	−0.958	0.338
REV_BT	0.015	0.675	0.500	−0.010	−0.664	0.507
REV_PT	−0.096	−1.003	0.316	0.037	0.559	0.576
REV_TR	−0.004	−0.608	0.543	0.004	0.929	0.353
AR(1)	0.010	1.840	0066 **	0.039	7.237	0.000 ***
rho	0.328	49.044	0.001 ***	0.205	28.908	0.000 ***
Log Likelihood	66,488			76,638		
Observations	24,694			24,694		
Period	2009–2020 (12)			2009–2020 (12)		
No. of cross-section units (municipalities)	2094			2094		

Panel estimation, fixed effects model with a spatial correlation term; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
Source: Own estimations.

Table 4
Determinants of the changes of land take for all purposes, and land sealed – spatial econometrics.

	Dependent variables					
	CHANGE_ALL			**CHANGE_SEALED**		
	Coefficient	t-stat.	Prob.	Coefficient	t-stat.	Prob.
Explanatory variables						
POP	−0.067	−1.498	0.134	−0.044	−0.984	0.325
POP^2	0.005	1.570	0.116	0.005	1.627	0.104 *
POPDev	−1.044	−65.106	0.000 ***	−1.043	−64.274	0.000 ***
INC	−0.026	−3.075	0.002 ***	−0.035	−4.142	0.000 ***
EDU	0.012	0.281	0.779	−0.045	−1.053	0.292
UNEMPL	−0.339	−6.149	0.000 ***	−0.269	−4.836	0.000 ***
SHARE_CONSTR						
SHARE_TRANSP						
SHARE_USE	−0.941	−51.173	0.000 ***			
SHARE_SEALED				−1.831	−45.786	0.000 ***
FISC_FREE	0.000	−0.074	0.941	0.001	0.376	0.707
FISC_DEBT	0.003	4.463	0.000 ***	0.003	4.230	0.000 ***
REV_RS	−0.001	−0.124	0.901	0.005	0.632	0.527
REV_BT	−0.002	−0.161	0.872	0.002	0.105	0.916
REV_PT	−0.058	−0.912	0.362	−0.073	−1.137	0.256
REV_TR	0.000	−0.016	0.987	0.002	0.536	0.592
AR(1)	0.020	3.856	0.000 ***	0.024	4.368	0.000 ***
rho	0.267	38.970	0.000 ***	0.272	39.984	0.000 ***
Log Likelihood	77,732			77,419		
Observations	24,694			24,694		
Period	2009–2020 (12)			2009–2020 (12)		
No. of cross-section unit (municipalities)	2094			2094		

Panel estimation, fixed effects model with a spatial correlation term; * ** $p < 0{,}01$, * * $p < 0{,}05$, * $p < 0{,}1$.
Source: Own estimations.

Table 5 in the Appendix). In our models, municipal land use decisions cannot be explained by the ideology of the majority party in the municipal council, by the classification of the municipality as urban, intermediate or rural according to the 'Urban-Rural-Typology' of the Austrian Statistical Office (STAT), nor by the age distribution of the population, the importance of tourism or the number of secondary residences.

While we did not include these variables in our models as they did not improve the explanatory power of the estimations, alternative specifications as well as tests for a reverse causality between land use decisions and fiscal variables were also employed. On the one hand, the specifications presented in this paper proved to be the most robust ones. However, only a specific spatial correlation was taken into account (i.e. land use decisions of municipality A were correlated with decisions of municipality B).[6] On the other hand, we also estimated models with reverse causality, such as land take as a determinant of fiscal variables. The results – not displayed here (see Bröthaler et al., 2023, for details) – broadly corroborate the findings of this paper. Municipal debt and the reduction of municipal cash flow levels could be influenced by expansionary land consumption. This result further indicates that municipalities cannot improve their fiscal position through expansive spatial development, but – on the contrary – can worsen their budgets, especially through dispersed zoning.

All in all, the results of the econometric study show only a very weak correlation between land consumption and cash inflows (e.g., certain revenues). However, expansive land use decisions seem to deteriorate the free cash flow and municipal debt levels. In addition, a number of other socio-economic variables have a strong influence on land use changes as well as on the stock of specific forms of land use – all of which may be interpreted as a manifestation of the growth paradigm in Austrian spatial policies as discussed above:

- The size of the municipality (population) is a key variable in describing land consumption: Smaller (less populated) communities tend to have above-average land take.
- All other things being equal, communities with above-average population growth – due to higher population density – generally have below-average land take.
- Socio-economic and demographic variables alter land use; for example, communities with above-average household incomes are more land-intensive.
- The scarcity of available land, i.e., the share of sealed land to the total land potentially available for residential and commercial purposes, also influences land use.

Contrary to the expectations of some policy-makers, fiscal variables only have little influence on land use decisions.

(1) There is a positive correlation between expansive land use and the level of municipal debt, especially with regard to changes in construction and transport as well as total land use and sealing. It may be that municipalities with higher (expected) debt levels designate (and use) more land in the hope that the perceived additional revenues will reduce the debt burden. A second possibility would be that higher debt levels are simply the result of more intensive land use, as this requires higher infrastructure expenditure.

(2) The municipal cash flow is slightly negatively correlated with the change in land take for buildings.

(3) In terms of current revenues, there is a correlation between the change in sealed surfaces and the municipal revenue shares, as well as the property tax. More intensive sealing is influenced by (expected) higher municipal revenue shares, but only weakly. (However, these additional revenue shares do not appear to improve the fiscal position, as additional sealing is correlated with higher municipal debt, as discussed here).

Before discussing policy conclusions, we need to point to the politico-economic model sketched above as the foundation for our empirical estimations. As described above, municipal decision-makers seem to believe that their fiscal position could be improved by expansive land use policies – which is clearly not the case. A possible behavioral explanation could be that decision-makers are prone to "fiscal illusion",

[6] Other spatial correlations, such as correlated explanatory variables or residuals, are not considered in this paper due to restrictions of space.

a public finance theory that suggests that decision-makers do not have full information about or oversee all the financial implications of their decisions. This leads to inefficient and costly decisions as they underestimate the costs and financial burdens associated with expansive land use decisions. Furthermore, the various instruments of the fiscal equalization system such as grants for municipalities with high fiscal deficits may work as an incentive for moral hazard. This means that decision-makers may be inclined to take more financial risks because they expect to be bailed out if the fiscal position becomes unsustainable.

Another explanation could lie in 'misguided' expectations. If decision-makers held rational expectations regarding the fiscal position of the municipality, they would behave differently (i.e., devote less land to construction, or pursue more sustainable land use policies by focusing on density and renewal of the existing building stock). Finally, they may be prone to moral hazard, and may also face permanent incentives to externalize the costs of their land use decisions. On the one hand, external costs in the form of loss of soil functions and biodiversity, and of climate change, can be externalized to the region and the province as a whole, and to the global community in the case of producing greenhouse gas emissions (via unsustainable modes of transport or a reduction of the carbon sink of the soil). On the other hand, unsustainable land use practices that lead to higher municipal debt can be offset by the Austrian system of fiscal federalism: the national and provincial regulations provide specific support for municipalities with unsustainable levels of debt or high municipal deficits. The fiscal federalism system thus works like an insurance, providing incentives for moral hazard behavior.

Beyond these politico-economic arguments regarding municipal land use decisions, it can be argued that there are even more fundamental assumptions about the outcomes of expansive land use. The growth paradigm still prevails in the Austrian spatial planning system (Müller et al., 2024; cf. Durrant et al., 2023). Interestingly, both the legal frameworks, the governance system as well as the diverse strategies and commitments to curb additional unsustainable land take and land sealing include all the instruments, tools and mechanisms that could potentially lead to a sustainable spatial development – while in reality, they are not effective in preventing an unsustainable spatial development. This is due to the specific contexts of local decision-making. From an economic perspective, municipal decision-makers (mayors, municipal councils) neither face hard constraints nor sufficient incentives to change their local land use plans. Empirically, this paper identifies many drivers that may be based on this growth paradigm in spatial development.

Thus, new instruments and strategies need to be considered to leave the path of unsustainable land use and land sealing. The key phrase of the scientific spatial planning community is to attach a price tag on each and every decision that would increase residential, commercial and infrastructure land in an unsustainable way. This approach can be justified on the basis of the econometric estimations and the politico-economic model of this paper: Attaching a price tag on additional land consumption would raise awareness among local decision-makers, in particular, in less populated municipalities, that land consumption is costly both for the municipal budgets and for the surrounding regions. A new tax would, for example, tackle the market failure of the external costs of land consumption and land sealing, and the planning failure in terms of behavioral imperfections (e.g., fiscal illusion, moral hazard).

Two new instruments have thus been proposed by the authors of this paper in a recent research report to the Austrian Ministry of Finance (Bröthaler et al., 2023). It is important to note that the proposed new instruments could be introduced into the Austrian fiscal constitution without designing a completely new governance system. Thus, other promising instruments such as (tradable) land use certificates (e.g., Henger and Bizer, 2010) were not considered because they could not be easily integrated into the existing legal frameworks. On the one hand, in the case of expansive zoning, municipalities should have to pay a specific regional tax (levy) to the provincial government, which would be earmarked for biodiversity conservation and protected areas. Tax rates could be differentiated for different purposes (e.g., zoning for detached single-family homes would be taxed at a higher rate than zoning for social housing in the city center). Such a tax would signal to local decision-makers that their unsustainable land use is costly, and that an additional soil sealing needs to be compensated. This intragovernmental tax would be directed towards public decision-makers.

On the other hand, private decision-makers, such as property owners and developers should be confronted with a price signal in the form of a zoning or land use tax, which from an economic perspective could also function as a property value tax. Since the value of property can increase significantly in the course of expansive zoning, there is a strong economic incentive to purchase and develop land. Such economic incentives could be reduced through such a zoning tax – which would also be paid to the regional government and used to establish new protected areas, and to conserve biodiversity.

This paper provides an overview of important drivers of unsustainable land use decisions in the Austrian planning context. However, a detailed analysis of the decision-making process itself from the viewpoint of political science has to be left to future research efforts.

CRediT authorship contribution statement

Grinzinger Elias: Writing – review & editing, Investigation, Data curation. **Getzner Michael:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Bröthaler Johann:** Writing – review & editing, Supervision, Software, Methodology, Investigation, Data curation. **Neuhuber Tatjana:** Writing – review & editing, Software, Methodology, Investigation, Formal analysis, Data curation. **Dillinger Thomas:** Writing – review & editing, Investigation, Funding acquisition, Conceptualization. **Kanonier Arthur:** Writing – review & editing, Investigation, Funding acquisition, Conceptualization.

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.

Appendix

Table 5
Dependent and explanatory variables

Variables	Variable labels	Description and operationalization
Dependent variables (land use changes):		
Land take for construction	CHANGE_CONSTR	Change of land take (consumption) for construction (m^2 per capita, from t−1 to t, ln)
Land take for transportation	CHANGE_TRANSP	Change of land take (consumption)for transportation (m^2 per capita, from t−1 to t, ln)

(*continued on next page*)

Table 5 (*continued*)

Variables	Variable labels	Description and operationalization
Land takefor all purposes	CHANGE_ALL	Change of land take (consumption)for all development purposes (m^2 per capita, from t−1 to t, ln)
Sealed land	CHANGE_SEALED	Change of land sealed (m^2 per capita, from t−1 to t, ln)
Explanatory variables:		
Population	POP	Number of residents (ln)
Change of Population	POPDev	Change of the number of residents (ln %)
Income	INC	Average personal income of tax payers (ln EUR)
Education	EDU	Share of residents with a college/university degree (% of all residents)
Unemployment	UNEMPL	Share of unemployed residents to total population (% of all residents)
Scarcity of land for construction	SHARE_CONSTR	Ratio of construction land to total settlement area (% at t−1)
Scarcity of land for transportation	SHARE_TRANSP	Ratio of transportation land to total settlement area (% at t−1)
Share of total land use	SHARE_USE	Ratio of land devoted to all purposes (e.g. construction, transport) to total settlement area (% at t−1)
Share of total land sealed	SHARE_SEALED	Ratio of total land sealed to total settlement area (% at t−1)
Municipal cash flow	FISC_FREE	Ratio of municipal cash flow to total current revenues (%)
Municipal debt	FISC_DEBT	Ratio of municipal debt to total current revenues (%)
Municipal revenues from shared federal taxes	REV_RS	Ratio of revenues from shared taxes to total municipal revenues (%)
Municipal revenues from the local business tax	REV_BT	Ratio of revenues from the local business tax to total municipal revenues (%)
Land tax (property tax)	REV_PT	Ratio of revenues from the local land tax (property tax) to total municipal revenues (%)
Revenue from regional transfers for municipal investments	REV_TR	Ratio of revenues from regional transfers for municipal investments to total municipal revenues (%)
Explanatory variables that were tested but not included in the final estimations:		
Typology of municipality: urban	UR_TYP1	Summarized type according to the urban-rural typology (=1 for classes of 101, 102, 103)
Typology of municipality: regional center	UR_TYP2	Summarized type according to the urban-rural typology (=1 for classes of 210, 220)
Typology of municipality: rural, close to urban/regional center	UR_TYP3	Summarized type according to the urban-rural typology (=1 for classes of 310, 320, 330)
Typology of municipality: rural, periphery	UR_TYP4	Summarized type according to the urban-rural typology (=1 for classes of 410, 420, 430)
Political party of the mayor (APP)	PARTY_VP	Political party of the mayor (=1 for APP/Austrian People's Party)
Political party of the mayor (SPA)	PARTY_SP	Political party of the mayor (=1 for SPA/Social-democratic Party of Austria)
Tourism	TOURISM	Relevance of tourism for the local economy (=1 high relevance, according to the Austrian Statistical Office)
Secondary homes	SECONDARY	Ratio of secondary homes (% of total residents)
Young population	POP_30	Share of young residents up to 30 years (% of total residents)

Source: Own draft.

Data availability

Data will be made available on request.

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