EUROPEAN ZONING RESTRICTIVENESS INDEX

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ABSTRACT

This paper develops a composite index of zoning restrictiveness for major European functional urban areas. Existing measures of land-use regulation typically rely on a single proxy, self-reported surveys, or nationally aggregated procedural indicators, making them poorly suited for comparative research across European cities. To address this gap, the paper combines four standardized components: the number of land-use categories in zoning plans, realized tall-building heights relative to metropolitan size and growth, changes in local population dispersion between 2006 and 2021, and the time and number of procedures required to obtain construction permits. The resulting index is designed to provide a broader, regression-ready measure of land use restrictiveness for comparative urban analysis. Descriptive results suggest higher average restrictiveness in Southern Europe and in parts of Central and Eastern Europe, and lower average restrictiveness in several Northern European countries. The paper concludes by discussing the strengths and limitations of proxy-based measurement and the potential uses of the index in research on housing supply, urban development, and land-use policy.

JEL classification: C43, R12, R14, R31, and R52

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Introduction

Zoning restrictiveness, that is, how difficult it is to start building on a parcel of land, is a challenge to measure. This is because regulations governing land use and construction vary widely across cities. Often, even their core objectives differ widely. Spatial planning and zoning regulation in European cities is frequently intended to prevent urban sprawl, with examples including green belts around cities in the UK and stringently protected farmland around cities in other countries (Gant et al., 2011; Ehrlich et al., 2018; Perrin et al., 2018; Oliveira et al., 2019; Tobias & Price, 2020). In contrast, elements of American cities, such as single-family housing and low-density zoning rules, incentivize urban sprawl (Pendall, 1999; McConnell et al., 2006; Strully et al., 2025). Some cities rely heavily on use-based zoning that strictly delineates building function and land use, while others emphasize urban form, including building envelope, frontage, façade treatment, and height continuity (Hirt, 2007, 2013; Talen, 2009; Garde et al., 2015; Choi, 2023).

Every zoning policy represents a trade-off between costs and benefits. Zoning regulation is motivated by (mostly) negative externalities caused by new construction and land use. If a polluting factory is built on a plot adjacent to your house, it will push the value of your property downwards, so city residents seek protection via regulation. Polluted air from traffic, noise from trains or a nearby football arena, and smell from a sewage treatment plant are all significant externalities with heavy influence on quality of life as well as the price of residential property exposed to them. Some externalities are gentler and change gradually, such as the neighbors we have. No one wishes to live in a high-crime neighborhood, and as crime is associated with low-income neighborhoods (for example, Pratt & Cullen 2005; Santaularia et al. 2022), this might be a reason why affordable and low-income housing often faces stiff local opposition.

There are many externalities present on land markets, but in the context of cities, none is as strong as the positive externality of access to a large job market. In fact, such access is the primary reason why real estate in cities is more expensive than in small towns or rural areas. The position of a piece of land and its distance to the job market and favorable travel connections determine the majority of a parcel's value. The old realtor's saying "Location, location, location" comes to mind.

Overtly restrictive zoning slows the pace of construction, pushes property prices up, and, by lowering the elasticity of supply, increases housing price volatility (for example Glaeser & Gyourko 2003, Quigley & Raphael 2005, Caldera-Sánchez & Johansson 2013) and slows the development of cities, with the most adverse effects impacting low-income city residents (Bertaud, 2018). Restrictive plans also limit architectural variety, as prescriptive rules force developers into repetitive designs (Bertaud, 2018). What's more, zoning also limits the creativity of residents. If it is difficult, time-consuming, or outright impossible to start a new café, repurpose an old building, or to take down a structure and replace it with a new one, owners often forgo these plans (Conejos et al 2016, Been et al. 2016).

This paper aims to provide a comprehensive measure of zoning restrictiveness for the 100 largest metropolitan areas in the EFTA (that is, the EU, Norway and Switzerland). This has not previously been attempted, and such a measure for European research is missing. Our approach is different from similar attempts made in the United States and other countries, as rather than rely on one measure of zoning restrictiveness, we have compiled a composite index, looking at various aspects and the impact of zoning regulations and policies. Furthermore, the composite index, available per component as well as aggregated, is regression-ready. It is normalized and standardized, increasing ease of use for other researchers.

Our approach to the topic is purely academic, and we aspire for it to be as objective as possible. We recognize both the benefits and costs of zoning, and we aim to design the best measure of how restrictive plans are and prepare the measure for use by researchers interested in European cities and beyond. Our index does not, however, attempt to assess the effectiveness of zoning policies. That is a separate area of research, admittedly even more difficult to measure.

We also understand we are raising a political problem, one that needs to be solved by municipal or national politics. Residents of certain cities might prefer lower regulation and the affordable housing that results, while residents of other cities might prefer the benefits of zoning, such as a higher provision of public parks and quiet residential areas. As overall zoning restrictiveness has its costs, we see high added value in its measurement.

Literature review

How zoning forms/deforms cities

City structure, its density profile, road network, and spatial organization of buildings are a result of a continuous interplay between market forces and zoning regulations. While there has historically been very little zoning regulation, this has been gradually increasing. At first, premodern cities regulated street networks, as organically grown streets were incrementally encroached on by private buildings, resulting in insufficient areas dedicated to transport (Ferragud & García Marsilla, 2016; Stell & Tait, 2016; Lilley, 2015). Tiny, curved streets of many medieval towns and cities testify to the need to regulate. Medieval cities often also prevented construction on squares to preserve the location for trade, and on riverbanks, which were needed to load and unload ships, and around fortifications, including city walls and surrounding trenches (Masschaele, 2002; Reyerson, 1997; Coomans & Hermenault, 2024).

As time passed, zoning regulations gradually increased. Land use regulation origin is not monocausal; it emerged from public-health and nuisance-control concerns, especially the polluting industrial uses and other externalities (Schilling & Linton, 2005; Lewis, 2013; Fischel, 2004). The infrastructure of cities became more complex with the ascent of railways and affordable cars, and with the need to connect buildings to watermains, sewers, and electricity. The need to spatially plan these uses increased the role of zoning plans (Neuman, 2010; Knowles et al., 2020; Schilling & Linton, 2005). Density regulation aiming to reduce overcrowding followed in the form of density ceilings, floor-area-ratio (FAR) limits, and building-height restrictions (Joshi & Kono, 2009; Bertaud & Brueckner, 2005; Ding, 2013. This aspect of city planning deserves further examination here, as it heavily influences the structure of cities. While market demand, according to Alonso-Mills model, follows a gradual density decrease as commute increases from the central business district (CBD), many cities do not allow this gradual decrease to materialize, instead aiming at uniform hights in the whole blocks or even neighbourhoods (Bertaud & Brueckner, 2005; Hirt, 2007; Garde et al., 2015; Choi, 2023). If maximum height in some locations is fully used by builders, it means demand was fully exhausted and, very likely, that some demand was not satisfied, with zoning preventing additional floorspace that otherwise would have been built (Bertaud 2018).

Zoning is aimed at limiting externalities, mostly via dividing land into sectors, each with clearly specified allowed land use. Cities publish zoning plans, where these land uses are colour-coded and code-coded, and they split the land into residential, commercial, industrial, and other uses. Keeping industrial use further away from residential use is meant to limit possible disturbance and protect property values. Some cities have a very high number of strictly defined land uses. In our analysis of European metropolitan

areas, the median number of land use categories was 68.5. The highest number we identified was 304 in Lille, France.

Strangely, commonly used use-based zoning splits land per use category, rather than regulating specific rules for individual nuisances such as thresholds for noise, odor, or traffic. In fact, this performance-based zoning is employed very rarely (Baker et al., 2006; Frew et al., 2016; Schulze, 1960). Residential land is often the most intensively regulated part of zoning systems (Lens, 2022; Gyourko et al., 2021), and is both paradoxical and understandable: on one hand, residential land use does not generate the same scope of externalities as, for example, industrial use. On the other hand, the externalities that influence these residential areas are most acutely felt by the residents. This leads to it being more difficult to obtain permits for residential projects than environmentally more damaging industrial land use (Lukavec et al., 2024).

City planning and zoning regulations are not without costs. They often limit the supply of housing, resulting in higher prices (Hilber & Vermeulen, 2016; Ihlanfeldt, 2007). Complicated regulation also often prolongs the approval process, leading to lower supply responsiveness to changes in demand and to higher price volatility of local housing markets (Mayer & Somerville, 2000; Ball, 2011; Huang & Tang, 2012).

Furthermore, zoning often protects agricultural land at the edges of cities, which, on one hand, protects greenery in the areas surrounding cities. But it has also been found to induce leapfrog development and result in longer commuting journeys from small towns nearby. (Jun & Bae, 2000; Mace, 2018; Han & Go, 2019).

And lastly, a substantial portion of literature argues that zoning has not merely correlated with segregation but has often been used to create or reinforce it through explicitly racial zoning, and later, through exclusionary devices such as density limits, single-family zoning, and other residential restrictions (Shertzer et al., 2022; Whittemore, 2017; Lens & Monkkonen, 2016; Rothwell & Massey, 2009).

Zoning restrictiveness indexes

The most widely used index of zoning restrictiveness is WRLURI, which is based on a survey of zoning in over 2,600 municipalities in the United States. It has been issued in two versions, in 2008 and later updated in 2018 (Gyourko, Saiz, and Summers, 2008; Gyourko, J., Hartley, J., & Krimmel, J., 2021). It relies on responses to a 15-question survey in which local respondents provided information on lot requirements, length of approval process, rate of approval, density restrictions, and others. The index itself is a composite of these perspectives.

The survey's response rate was 38%, which is an obvious limitation, but the authors claim to have used logit models to control for sampling bias. A more significant problem is the self-reported nature of some components of the index. Some of the index's sub-questions rely on factual information, while others are opinion-based and rely on respondents' evaluation using a Likert scale. We consider it very likely that local officials would answer these questions differently in municipalities where housing prices are a subject of political discourse. This source of bias, however, is not addressed, and significantly reduces the reliability of the index.

Mleczko et al. (2023) attempt a similar methodology to the above-mentioned Gyorko et al, tracking the same measures, but instead of a survey of local officials, they use municipal codebooks and zoning ordinances. These are then parsed for indicators of zoning restrictiveness. The parsing results in 33 binary

and 7 numeric indicators, which are combined into 11 subindices. Some of these were manually rechecked on a subsample to verify the method's validity.

While this method is an obvious improvement on WRLURI, it still has weaknesses. The method relies on the codebooks/ordinances as the only source of data, and does not attempt to verify whether these are actually followed or what impact may be. Zoning in the States is known to have a strong role of zoning boards, which have the power to grant variances (approve land uses which conflict with codebooks) if they feel the development would benefit the location or the municipality overall. While by legal definition variances should be exceptions, in practice, they are used very often. Infranca (2023), for example, claims that in some jurisdictions, more than 90% of applications rely on variances. Gray (2022) claims that this leads to a strange situation where zoning boards push for overly strict zoning rules to which variances are often granted, concentrating power in the hands of the zoning boards. As it is not likely that the degree of variance is uniform across various municipalities, relying on codebooks/ordinances, at least in the context of the United States, is very likely to result in a skewed picture.

A Europe-wide or European Union-wide zoning restrictiveness index does not exist, presenting a serious research gap that our paper aspires to fill. There have, however, been limited efforts to calculate such indices in some European countries.

While the UK does not have a single WRLURI-style composite, researchers commonly rely on narrower proxy measures of zoning restrictiveness. For example, Hilber & Vermeulen (2016) use the average planning refusal rate, or the share of applications for residential projects that the Local Planning Authorities (LPAs) in England did not approve. Similarly, Ball (2011) uses planning delays, or the time the local authorities need to approve/reject applications as a proxy measure, to interpret housing supply responsiveness and subsequent price volatility.

These single-focus measures cannot be considered comprehensive indexes of zoning restrictiveness. This is due to the various zoning approaches we mentioned in the introduction. Planning authorities in the UK, for example, according to the World Bank's Ease of Doing Business index (World Bank Group, n.d.1) need only a few procedures for granting or refusing construction permits on paper. But this perspective does not tell us anything about other aspects of zoning, such as height restrictions, availability of land zoned for construction and more.

In Switzerland, Büchler & von Ehrlich (2023) construct multiple residential development stringency sub-indexes based on a municipal survey. In 20 questions, they query local officials about the supply of land, density requirements, permit fees, rejection rates, and others. The authors also use machine learning methods to fill gaps in the sample and correct for non-response bias. While this index is arguably the best and most comprehensive European effort in the area so far, the paper has left many aspects to be desired. As with WRLURI in the United States, here the authors rely on a Likert scale for multiple questions, allowing bias to enter the sample. Furthermore, even questions that could have been posed in a strictly fact-based way allow for interpretation; instead of asking whether the floor-to-area ratio or green space requirements are part of the municipal code, they ask whether they are relevant, allowing for subjective interpretation from local officials.

Barring these two instances (the UK and Switzerland), monitoring of zoning restrictiveness in Europe is sparse. With no universal, widely accepted indexes available, simple measures such as the number of permits granted, refusal rates, permit waiting periods, or permit backlogs are often used by researchers instead (for example: Lerbs, 2014; Hilber & Vermeulen, 2016; Ball, 2011).

The most cited measure of zoning restrictiveness index is the World Bank's Ease of Doing Business index, specifically its subsection Dealing with Construction Permits (World Bank Group, n.d.1). Its focus is on identifying the time and numbers of procedures needed to obtain all necessary permits before construction can start in various countries in the world. The index is a major achievement in this respect. It offers a global perspective, and it is comprehensive and meticulously prepared. It is widely used by researchers as a proxy for zoning restrictiveness (for example, Gete, 2014; Caldera & Johansson, 2013). That being said, its focus is narrow. It tries to compare the comparable, so the methodology tracks one specific type of building (a 2-storey warehouse located on a 10,000 square feet plot), meaning buildings in the cores of large cities are not included. Furthermore, the index looks specifically at laws and regulations, but does not empirically observe the length or number of procedures. In countries where the local offices use various exemptions to shorten or prolong the process or where the construction permits applications are subject to legal challenges by residents, environmental groups, and others, the process can vary widely from the critical paths identified by this index. Hallward-Driemeier & Pritchett (2015) compared the index values with Enterprise Surveys for Each Country and found only a very limited correlation.

And lastly, the index tracks data at the national level, but zoning regulations differ among regions and cities. Hallward-Driemeier & Pritchett (2015), for example, found that within-country variance (in this case, measured as the difference between the 90^{th} and 10^{th} percentiles) of time needed to obtain construction permits is 116 days, as reported by local businesses.

That being said, Dealing with Construction Permits is a high-quality index, which is why we have decided to include it as one section of our index to capture the procedural side of the zoning regulations.

Regulatory taxes applied to zoning

Some researchers, instead of trying to quantify the zoning restrictiveness, attempt to measure the price effect attributable to zoning. The main idea is that in a competitive market with a few zoning restrictions, housing (or any other real estate) should be available at close to production costs (that is, the cost of building materials, construction and land).

Glaeser and Gyourko (2003) and Glaeser, Gyourko, and Saks (2005) are two seminal papers in this respect. They attempt to calculate zoning regulatory taxes on house and apartment prices in 40 large cities in the U.S..

The main problem with this line of thinking is the fact that the whole residual price difference is attributed by the researchers to zoning restrictiveness. If some aspects of the price dynamics are not fully understood, or some factors are omitted, these are attributed to the zoning by default

Geography, amenities, construction-cost heterogeneity, and other supply frictions can hold prices above marginal construction costs. Furthermore, even in lightly regulated markets with high supply elasticity, such as in many southern and interior U.S. cities (Gyourko, Saiz, & Summers, 2008; Gyourko, Hartley, & Krimmel, 2021) prices move along with consumer demand, a result of strong local job markets and population growth (Hwang & Quigley, 2006; Jud & Winkler, 2002; Paciorek, 2013). Here, speculative dynamics generate temporary mispricing (Chinco & Mayer, 2016; Nathanson & Zwick, 2018). Price points in various years then result in supposedly different regulatory taxes, despite no change in zoning occurring.

Even more unexplored is the area of the competitiveness of the housing market, on which the above-mentioned approaches are based. The level of competitiveness is influenced by the degree of market concentration, or how many developers are present in any given real estate market and, subsequently, what their market power is to increase prices over costs. Market concentration is commonly assessed via calculation of the HHI index (for example: Beck et al., 2012; Cheung et al., 2017; Zheng et al., 2023), which is usually computed for a geographically defined local market such as a city or metropolitan area (Somerville, 1999; Beck et al., 2012; Zheng et al., 2023). But whether buyer demand is locationally elastic, that is, whether buyers are willing to move neighborhoods when price differences arise, is insufficiently explored in current research. We do, however, have partial indications showing that buyers pay premiums for neighborhoods with better schools (Black,1999; Kane et al., 2006) and to self-segregate along racial and educational lines (Bayer et al., 2007; Bayer & McMillan, 2012). This means that households do not treat all locations within the metro as close substitutes, undercutting the metro-wide competitive market argument. This has major implications for the validity of the competitiveness of housing markets, as buyers are likely to pay higher margins for the neighborhoods of their choice. These premiums, again, may be wrongly attributed to the influence of zoning. As a tool to assess the market competitiveness of real estate development at the Metropolitan area or city level, HHI is still useful. But it is a coarse measure, and for the reasons mentioned above, it is advisable to calculate it at the neighborhood level instead.

Methodology

To quantify the overall restrictiveness of zoning plans and the construction process overall, focusing on one specific aspect is an option, but one without much practical use, as no specific feature of zoning seems to be dominant. Zoning restrictiveness can take many forms: overall complexity, low availability of land zoned for construction, height and density limits, permit delays, and more. One measure will necessarily measure just one aspect of zoning, leading to a skewed picture.

To solve this problem, we have borrowed methodology from other areas of science and finance, where, when a problem is a complex system and/or data is unreliable and proxy dependent, independent lines of evidence are used to strengthen inference. First, political polling – there are various methods of surveying an electorate for their voting intentions. There are telephone or online surveys, sampling frame, likely-voter screen, weighting, question wording, and many other factors. As all of these options lead to some bias, with the polling error for any individual poll usually bigger than the expected statistical error. To achieve better results, poll aggregating websites such as FiveThirtyEight, Silver Bulletin and others average the number of individual, independent polls. As the errors resulting from methodological choices cancel each other out, these averages tend to be significantly more accurate than individual polls (Graefe et al., 2014; Shirani-Mehr et al., 2018)

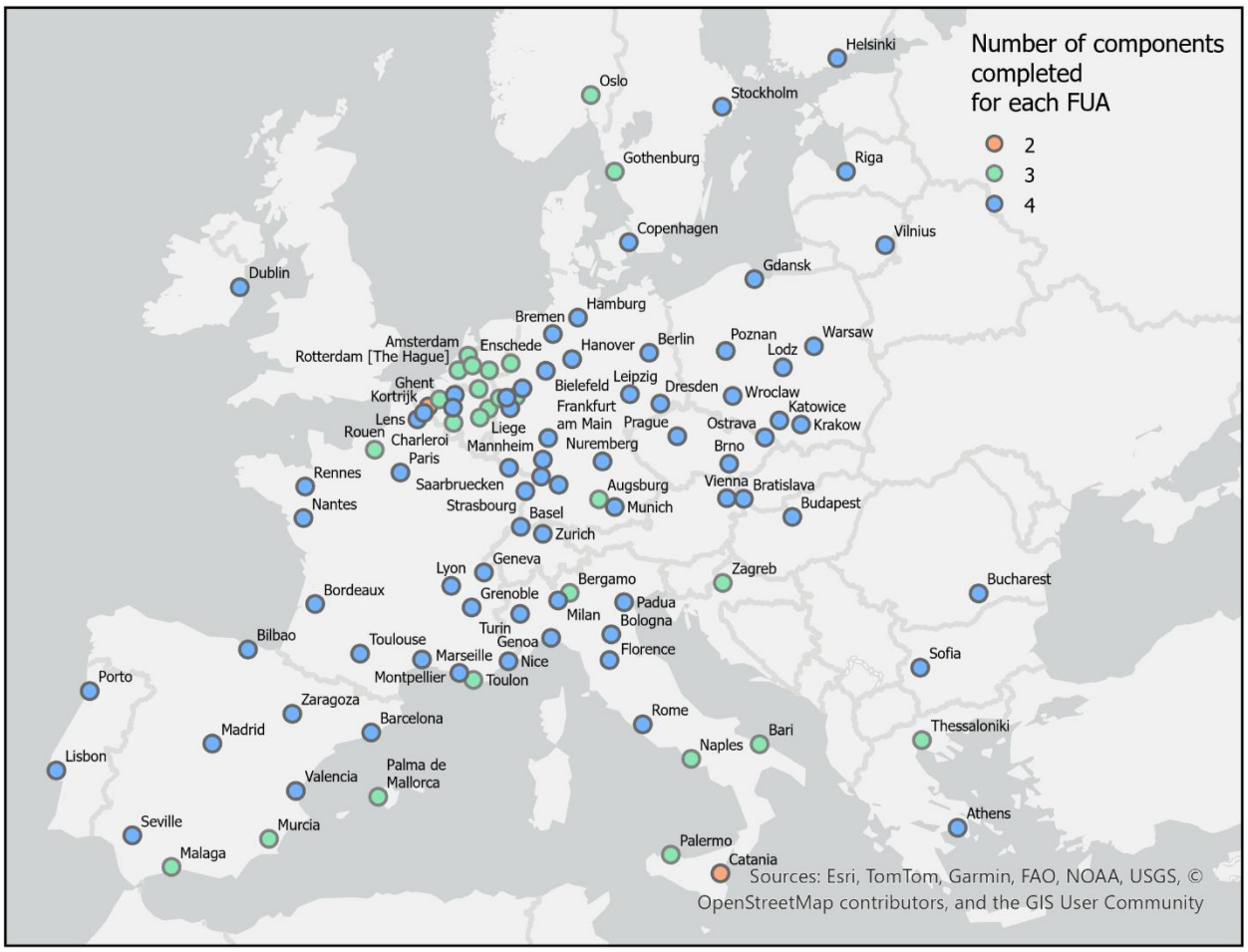
A similar methodology is employed in finance when evaluating private companies. There are a number of methods to be employed – income methods based on discounted cash flows (DCF), comparable companies analysis, and asset-based approaches. Each of these methods approaches the problem (a value of any given company) from a widely different angle and arrives at different values. While each of these values is likely, to a degree, to be incorrect, the average (weighted depending on the quality of data available and other reasons) is generally closer to the firm's true value than any of them alone (Yee, 2004, 2008; Demirakos et al., 2004; Erkilet et al., 2022).

Triangulation is used in many other areas of science – epidemiology (Lawlor et al., 2016), cosmology (Weinberg et al., 2013), particle physics (ATLAS Collaboration, 2012), or ecology and conservation biology (Schaub & Abadi, 2011), just to name a few.

We have decided to use similar logic to measure zoning restrictiveness of the 100 most populous metropolitan areas in the European Union, Switzerland and Norway, following the Eurostat Functional Urban Areas or FUAs, or cities and the commuting areas that surround them (Eurostat, 2024) to measure various aspects of zoning. FUAs were selected based on their 2021 population counts, which were the most recent complete data available when our data collection began. FUAs in Great Britain have not been included, as one component of our index relies on data from Eurostat, which the United Kingdom hasn't reported to since 2021 (Eurostat, n.d.).

The sample composition is displayed in the following figure:

Figure 1 – Sample composition



Our approach has four distinct components:

1) **Component 1: Number of land-use categories in zoning plans** – Almost all cities regulate their land use via zoning master plans, a set of plans which restrict the purpose for which the land can be used. To quantify this restrictiveness, we have identified the number of land-use categories

used in individual zoning plans as a good proxy measure for the overall complexity of zoning. The logic of this method is as follows: Some cities, based on our sample, have one category for parks, while other cities have five categories for parks. Some cities have over 50 various categories of residential constructions, each with different rules of what kind of houses can be built. The overall count of land use functions is therefore strongly indicative of the overall zoning restrictiveness. We have identified and quantified 84 zoning plans of cities around which the 100 largest FUAs in the European Union are centered. This component is calculated at the city's municipal boundary level. To our knowledge, this method has not been attempted by other researchers to date, although there have been attempts in a similar direction: Chakraborty et al. (2013) measure zoning restrictiveness from the diversity of housing types allowed, and Mleczko and Desmond (2023), who extract zoning-code dimensions from administrative texts and use them to create their measure of exclusionary zoning.

2) **Component 2: Building height** – Many European cities restrict building heights. There are many stated reasons for this regulation: architectural/design reasons, heritage protection, solar access/daylight, and concern about the congestion or crowding effects of overbuilding (Saakjans et al., 2026; Short, 2007; Littlefair, 2001; Hraška, 2019; Bertaud & Brueckner, 2005; Ding, 2013). Ideally, we would be able to collect a sample of recently built high-rises to be able to eliminate or limit outliers. This has, however, proven to be impossible for a number of smaller metropolitan areas in our sample, as there isn't sufficient data to be found online on the tallest buildings. To overcome this problem, we were forced to concentrate on the highest buildings (one per city) in the examined cities constructed since 2000. Because vertical growth is strongly related to city scale, we normalize our realized-height proxy by city size. We collected data from the Council on Tall Buildings and Urban Habitat (2024) and other sources. The area of the entire functional urban area has been used for this component.

3) **Component 3: Population coefficient of variation change** – Some cities have a more uneven distribution of people than others. This might be due to geographical constraints like mountain ranges, rivers, lakes, or sounds, but it can also be due to zoning restrictions. Urban parks and green spaces are classic local public goods or amenities with market-failure characteristics, and their supply and protection are typically shaped by public planning rather than the market (Geoghegan, 2002; Choumert, 2010). Cities with more parks have higher variability of population, as these areas are not inhabited (Wu & Plantinga, 2003). Binding height limits, especially in high-demand central or historic areas, can flatten the center, reduce housing output, and distort the density gradient (Bertaud & Brueckner, 2005; Brueckner et al., 2017; Jedwab et al., 2022**).** As urban models such as Alonso's model and its later modification show, given no physical constraints, the density of population should gradually decrease from the central business district. We decided to use this knowledge to add a dynamic component to our index – if the unevenness of population has decreased, the city gradient became more in line what the market driven Alonso-Muth-Mills (AMM) model expects (Alonso, 1964; Mills, 1967; Muth, 1969), or increased over the period between 2006 and 2021 (period was chosen due to data availability, see below), suggesting the regulation became more stringent. To do this, we used Eurostat population census 1km grid statistics and calculated whether the coefficient of variation (standard deviation divided by mean population count) of any 1km square and its 8 closest neighbors has increased or decreased. This approach measures whether the city was protecting greenery, public places, and historical neighborhoods, or whether these were gradually built over. Data used for this section: Eurostat 2006 and 2021 population census grid data (Eurostat, 2012

and Eurostat, 2023). The area of the entire functional urban area has been used for this component.

4) **Component 4: Length and the number of procedures needed in the approval process** – The length and number of procedures in the approval process capture one dimension of regulatory stringency. Several cross-country housing studies use the World Bank *Doing Business* "dealing with construction permits" indicators, especially the number of procedures and days to obtain a permit, as proxies for the procedural burden of land-use regulation or for housing-supply elasticity (Caldera & Johansson, 2013; Kuang & Wang, 2018). The benchmark is based on a standardized case(in order to simplify and unite its methodology: a simple two-storey warehouse in the largest business city, and records the procedures, time, and cost needed to obtain the approvals required for that project (Bröchner et al., 2021; Fauth & Soibelman, 2022; Fauth et al., 2025). Because it examines a single project type and a permitting path, it offers a very narrow, but still fairly representative perspective on the procedural component of zoning restrictiveness. Realized project-level delays can be substantially longer or more variable than the benchmark suggests (Hallward-Driemeier & Pritchett, 2015; Ball, 2011; Wrenn & Irwin, 2015). The warehouse focus may also understate barriers relevant for housing, because residential and mixed-use developments often face stronger local opposition and, in some settings, longer permitting processes than industrial development (Whittemore & BenDor, 2019; Klement et al., 2023; Lukavec et al., 2024). Despite these shortcomings, the dealing with construction permits index is a high-quality measure, based on measurable procedural requirements for new construction. While it would not be advisable to use it in isolation, it adds an important perspective to our overall index.

We believe that the resulting average will incorporate information from various sources and, as such, will be more balanced than any other narrow proxy measure and closer to the actual zoning restrictiveness. The output of the analysis is the results of each of these components, plus a simple average of the components, standardized. While we don't believe there is any reason the components should have the same weight, we could not find any sufficiently strong rationale for adjusting the weights to give certain components bigger weights. We trust that researchers in need of this index can adjust the weighting to fit their specific research purposes.

In this paper, we offer a robust alternative to other partial zoning restrictiveness measures, which we discussed in the Literature review. Because our measure is based on a wider array of zoning perspectives, with 2 components concentrating on the regulation and 2 components on observed impact, we believe our index is more representative. The final measure is also standardized in a close-to-normal distribution, so it can be used readily by any researcher who finds themselves in need of it.

Not all components could be completed for all 100 FUAs. The breakdown of the component inclusion is in Table 1 below.

Table 1 – Index component composition

Number of Components completed for a FUA	Number of FUAs
4	72
3	26
2	2
Total	100

See the methodology sections for each component for explanations and the Limitations section for the implications.

Component 1: Number of land-use categories in zoning plans

Complexity and restrictiveness of zoning regulation demonstrate themselves, among other things, in the number of land-use categories cities have. While to a large degree simplistic, one possibility to quantify this aspect of zoning complexity is to count the number of land use regulations. We have explored zoning plans of all 100 cities that act as the central municipalities in our sample of 100 functional urban areas, for which we managed to collect data for 84. The most notable omission in our sample for this component is FUAs in the Netherlands; Dutch FUAs were excluded from this component because, since January 1, 2024, Dutch municipalities have operated under the Omgevingswet/omgevingsplan framework, an integrated environment-and-planning regime that is not directly comparable to conventional municipal land-use master plans elsewhere in the sample (Korthals Altes, 2016).

To assess the number of land-use categories, we have counted each land-use category listed in the zoning plans and associated documentation, which can be considered to occupy a spatial area. We have, however, decided to omit the line infrastructure – watermains, electricity connections, rail, and road network. This was due to significant categorization differences and differences in the amount of detail. Cities with an industrial history, for example, have large rail networks, while others do not. We deem the infrastructure detail in cities largely irrelevant to our objective to discover how restrictive land use rules are.

Other cities that required particular methodological choices were cities in Poland, seven in total. In Poland, land-use regulation is frequently fragmented across multiple local plans with incomplete citywide coverage. For Warsaw, as of May 2025,, there were 384 plans covering 47,44% of the area of the city (Urząd m.st. Warszawy, n.d.). For Polish cities we have approximated regulatory granularity by sampling plans across urban zones rather than assuming a single unified citywide master plan. We based this calculation on a sample of 30 urban plans per city, stratified between central and suburban areas and along the east/west and north/east orientation. Some of the plans cover larger areas with many land-use categories, because other plans cover only small areas of the cities, such as a single city block or even a single park. The average number of categories would not suit our purpose, as it would result in a severe undercount. Adding categories from various plans was also not possible, as their methodology (especially for older plans still in force) is not unified, and categories overlap. That is why we have decided to use the highest count in our sample for each city as the only way forward. This count was then multiplied by the ratio of the city area covered by plans, as the land currently not covered by plans is not restricted in land use.

The final dataset of land-use categories for each FUA was logarithmically transformed (as the overall distribution showed a strong positive skewness)

$$L_f = log(X_f) \quad (1)$$

and standardized via z-scores.

$$Z_{f1} = \frac{L_f - \overline{L}}{s_L} \quad (2)$$

where

(3) $$\overline{L} = \frac{1}{n}\sum_{f=1}^{n} L_f$$

and

(4) $$s_L = \sqrt{\frac{1}{n-1}\sum_{f=1}^{n}\left(L_f - \overline{L}\right)^2}$$

Where:

f	index of a functional urban area (FUA)
n	number of FUAs in the dataset
X_f	original number of land-use categories in FUA f
L_f	log-transformed value of X_f
$\overline{L}$	mean of the log-transformed values across all FUAs
s_L	sample standard deviation of the log-transformed values across all FUAs
Z_{f1}	standardised value of L_f, for component 1, expressed as a z-score

Results can be found in Appendix 1.

Component 2 - Building height

Restrictive city planning often manifests itself in difficulty of construction of very high buildings, even where economic forces would otherwise result in high floor-to-area ratios (FAR). Housing density is a result of a local demand for housing and other building classes, and the central locations of cities see the highest demand because of their accessibility to the largest share of the job market and attractiveness of companies to locate there (Bertaud 2018). In an unregulated market, developers create an additional supply of floor space by building up. If a city has fewer buildings than its size would predict, it is very likely to be a result of regulation rather than any other factors. Urban planners often discount the role of markets in shaping densities and point to the desirable role of regulation in uniting building heights at a social level, which supports walkability, built-form coherence, and prevents overcrowding (Saakjans et al., 2026). This argument, while valid, means that if applied, local demand for housing will not be satisfied. Developers build housing at a unified height only if local demand is high enough to create supply in its entirety, meaning additional supply is not allowed to be built, and prices go up (Bertaud 2018). Unstable ground is often listed as a reason not to build high-rises (Ahlfeldt & Barr, 2022), but this is technologically incorrect, as tall buildings are often built on soft/complex soils using piled-raft/deep-foundation systems (Poulos, 2016) as the construction of skyscrapers exceeding 300 meters in Dubai (UAE), Mexico City (Mexico) or Jeddah (Saudi Arabia) show.

Another component of our index looks into whether these signals of planning regulation are demonstrated in our cities. As we want to establish the current zoning restrictiveness, we collected data on the skyscrapers and other tall structures (office, residential or public use, but excluding technological or lookout towers) built since 2000 (skyscrapers often take more than 10 years of planning and construction) for the 100 most populous functional urban areas (FUAs) in the EU, Switzerland and Norway from the Council on Tall Buildings and Urban Habitat (CTBUH, 2024), Skyscraper Source Media (2024), Archi-Guide (2024), Groupe-H (2024) and Mageba Group (2024). For 13 out of 100 large FUAs, we were

unable to identify even one tall structure. Among identified buildings, the lowest observed height was 32.9 meters (Stade Bollaert-Delelis building in Lens, France).

To quantify whether a city/functional urban area is restrictive or liberal regarding the construction of tall buildings, we have to control for the population of the FUA and for the demand for new construction. Larger metropolitan areas have a more specialized workforce and more dominant service sectors, which both tend to cluster in the central areas of cities (Duranton & Puga, 2005; Elvery, 2010; Rubalcaba et al., 2013) Furthermore, cities with vibrant labor markets and large job creation will see more demand for new construction in these labor centers. As data on job creation is not consistently available across all FUAs, we use a proxy variable – population growth between 2006 and 2021, based on the Eurostat census data (Eurostat, 2024). Vibrant labor markets attract workers, so population growth is highly correlated with the number of jobs created (Blanchard & Katz,1992). When running a regression with population and population change, the residuals showed very strong heteroskedasticity, which persisted even after various variable transformations were applied. The problem was solved only after the population and population change variables were multiplied and used as one variable. The resulting model is described below. The regression table, kernel density, and the regression Q-Q plot are included in Appendix 5.

After controlling for metropolitan population and population change, we consider lower-than-expected realized tall-building heights to be consistent with tighter planning regulation. To a degree, this is a simplification, as historical protection, geology, and demand composition also matter. But we do not consider these significant, as construction technology allows for skyscraper construction even on unstable ground (Katzenbach & Leppla, 2015; Poulos, 2016) and historical protection does not cover the entire area of the examined FUAs.

The regression model is defined as:

$$H_f = \alpha + \beta X_f + \varepsilon_f \tag{5}$$

where

$$X_f = P_f \times G_f \tag{6}$$

Fitted value and residual

$$\widehat{H}_f = \hat{\alpha} + \hat{\beta} X_f \tag{7}$$

$$\hat{\varepsilon}_f = H_f - \widehat{H}_f \tag{8}$$

Standardization of the residuals

$$Z_{f2} = \frac{\hat{\varepsilon}_f - \overline{\hat{\varepsilon}}}{s_{\hat{\varepsilon}}} \tag{9}$$

Where:

f	index of a functional urban area (FUA)
H_f	observed building-height value for FUA f
P_f	population of FUA f in 2021, expressed as number of people

G_f	percentage population change of FUA f between 2006 and 2021
X_f	explanatory variable used in the regression
α, β	regression coefficients
ε_f	error term in the regression model
$\widehat{H}_f$	fitted building-height value for FUA f
$\hat{\varepsilon}_f$	residual for FUA f
$\overline{\hat{\varepsilon}}$	mean residual across all FUAs
$s_{\hat{\varepsilon}}$	standard deviation of the residuals across all FUAs
Z_{f2} =	standardised residual – result of the component 2

Results can be found in Appendix 2

Component 3: Population coefficient of variation change component

Zoning regulations often result in what becomes known as leapfrog development: If it is too difficult, too expensive to build, or if construction in certain areas is not allowed by local urban plans, developers build further. This phenomenon is well documented in UK cities with green belt regulations (Gant et al., 2011) and in German cities which restrict urban sprawl (Siedentop et al., 2016). But leapfrog development can also be a result of geographical constraints such as seas, rivers, mountain ranges, and geology.

For our index, we have chosen a change of the coefficient of variation in the period between 2006 and 2021, based on Eurostat 1km^2 population grid data. As it is a dynamic measure, it is not impacted by geography and geology, as we do not expect these to have changed meaningfully during the given 15-year period. The rationale for this measure is as follows: According to the Alonso-Mills urban model, households optimize their location as a tradeoff between size, price, and commuting time to the job market (Alonso, 1964; Mills, 1967; Muth, 1969). In markets with no geographic or geological restrictions, this results in cities with smooth population gradients, with the population density gradually decreasing with commuting time from the city center. If there are any breaks in the gradient, this is usually due to non-market conditions such as regulation and other factors (such as self-segregation along income or racial lines). In case of zoning regulation becoming more or less restrictive during our 15-year period (and holding the non-market factors constant), this would demonstrate itself in the gradient becoming less or more smooth, respectively.

Furthermore, provision of open and green spaces is typically shaped by public planning and land-use regulation. Because such spaces occupy land, they contribute to uneven density patterns (Wu & Plantinga, 2003). This again shows in the uneven distribution of population in the 1km2 population grid.

For each 1 km² grid cell i in year t, compute the standard deviation of the population values in the 3×3 neighbourhood centered on i (that is, the focal cell plus its 8 neighbours):

(10) $$SD_{i,t} = \sqrt{\frac{1}{9}\sum_{j \in N(i)} \left(P_{j,t} - \overline{P}_{i,t}\right)^2}$$

with

(11) $$\overline{P}_{i,t} = \frac{1}{9}\sum_{j \in N(i)} P_{j,t}$$

To calculate the coefficient of variation, we normalized the local dispersion by the average population per grid cell in functional urban area f:

$$CV_{i,t} = \frac{SD_{i,t}}{\overline{P}_{f,t}} \tag{12}$$

with

$$\overline{P}_{f,t} = \frac{1}{n_f}\sum_{i \in f} P_{i,t}. \tag{13}$$

Because the distribution of the normalized values is skewed, we applied a logarithmic transformation:

$$L_{i,t} = \log\left(CV_{i,t}\right) \tag{14}$$

Next, we compute the change for each grid cell by simple subtraction:

$$\Delta L_i = L_{i,2021} - L_{i,2006} \tag{15}$$

And lastly, for each functional urban area, calculate the simple average across all grid cells belonging to that FUA:

$$\Delta L_f = \frac{1}{n_f}\sum_{i \in f} \Delta L_i \tag{16}$$

The FUA-level change measure was then standardized by converting ΔL_f to a z-score across all FUAs in the sample:

$$\Delta L_f^{(z)} = \frac{\Delta L_f - \overline{\Delta L}}{s_{\Delta L}} \tag{17}$$

Where:

i	Index of a 1 km² grid cell.
j	Index of a neighboring grid cell within the local 3×3 neighborhood.
$N(i)$	Set of 9 cells consisting of cell i and its 8 neighbouring cells.
t	Time period, here 2006 or 2021.
f	Functional urban area (FUA).
n_f	Number of grid cells in functional urban area f.
$P_{j,t}$	Population in grid cell j at time t.
$\overline{P}_{i,t}$	Mean population across the 9-cell neighborhood centered on cell i at time t.
$SD_{i,t}$	Standard deviation of population in the local 3×3 neighborhood around cell i at time t.
$\overline{P}_{f,t}$	Average population per grid cell in functional urban area f at time t.
$CV_{i,t}$	Coefficient of variation of local cell clusters.
$L_{i,t}$	Log-transformed dispersion measure.

ΔL_i Change in the log-transformed dispersion measure for grid cell i between 2006 and 2021.

ΔL_f Average change in the log-transformed dispersion measure across all grid cells in functional urban area f.

99 functional urban areas were used to calculate this messure, as the data for 2006 is not available for Zagreb, Croatia.

Results can be found in Appendix 1.

Component 4: Length and number of procedures needed in the approval process component

One of the best and most often cited benchmarks for construction restrictiveness is the Ease of Doing Business report published by the World Bank, specifically its subsection entitled Getting Construction Permits. (World Bank Group, n.d.1). In this report, a standardized industrial project is assessed under various countries' procedures and a number of construction and other permits, and the time necessary to complete them to be allowed to start the construction.

It can be objected that the methodology is very limited, as it deals only with industrial buildings (World Bank Group, n.d.2), the World Bank has a lot of merit thanks to its unified methodology which is followed in all countries. We would not advise using this data in isolation as a benchmark for construction restrictiveness, but the index captures yet another aspect of the zoning regulation: how difficult it is to obtain the permits, both in respect of the number of procedures and in respect of time required to do so (World Bank Group, n.d.1).

For our purposes, we take the index's raw data for all European countries in which our sample of the 100 biggest FUAs are located, for both the number of procedures and for time to obtain the construction permits. We decided not to include the costs measure, which is also tracked by the Ease of Doing Business. In many countries, administrative costs are negligible compared to the opportunity costs of delays. Waiting for permits while owning the land means delay in profits (Wrenn & Irwin, 2015). This brings us to the weakest point of the inclusion of this measure: dealing with construction permit benchmarks is prepared for countries, but zoning policies are often heavily influenced by local city rules. While this is a significant problem, we maintain that inclusion of this benchmark in our index is valuable, as it is highly detailed and it is based on mostly reliable data.

We collected data on the number of procedures and the time required to obtain construction permits for countries in which functional urban areas are located. As both of the variables display positively skewed distribution, we logarithmically transform them.

(18) $$L_{D,f} = log(D_f), \qquad L_{P,f} = log(P_f)$$

In the next step, we standardize them.

(19) $$Z_{D,f} = \frac{L_{D,f} - \overline{L}_D}{s_D}, \qquad Z_{P,f} = \frac{L_{P,f} - \overline{L}_P}{s_P}$$

The final result is the average of both standardized logarithmically transformed time and number of procedures.

(20) $$Z_{f4} = \frac{Z_{D,f} + Z_{P,f}}{2}$$

Where:

f	index of a functional urban area (FUA)
D_f	permit time, measured in days, in the country where FUA f is located
P_f	numberr of procedures required to obtain a construction permit in the country where FUA f is located
$L_{D,f}$	log-transformed permit time for FUA f
$L_{P,f}$	log-transformed number of procedures for FUA f
$Z_{D,f}$	z-score standardized value of the log-transformed permit time for FUA f
$Z_{P,f}$	z-score standardized value of the log-transformed number of procedures for FUA f
$\overline{L_D}$	mean of the log-transformed permit-time values across all FUAs
$\overline{L_P}$	mean of the log-transformed procedure-count values across all FUAs
s_D	standard deviation of the log-transformed permit-time values across all FUAs
s_P	standard deviation of the log-transformed procedure-count values across all FUAs
Z_{f4}	component 4 final measure for FUA f

The z-scores for both time and procedures are the averaged, to obtain one overall measure.

Final index composition

The final index is calculated as an average of the results of each 4 components for each FUA, which is then re-standardized, so the final z-score follows the standard normal distribution.

(21) $$A_f = \frac{1}{4} \quad (Z_{f1} + Z_{f2} - \Delta L_f^{(z)} + Z_{f4})$$

and

(22) $$Z_f = \frac{A_f - \overline{A}}{s_A}$$

where

(23) $$\underline{A} = \frac{1}{n} \quad \sum_{f=1}^{n} A_f$$

f	index of a functional urban area (FUA), with f = 1, ..., 100
A_f	arithmetic means of the four component z-scores for FUA f
$\overline{A}$	mean of the FUA-level averages across all FUAs
s_A	standard deviation of the FUA-level averages across all FUAs
Z_{f1}	result for component 1

Z_{f2}	result for component 2
$\Delta L_f^{(z)}$	result for component 3
Z_{f4}	result for component 4
Z_f	final re-standardized index for FUA f
n	number of FUAs in the dataset, with n = 100

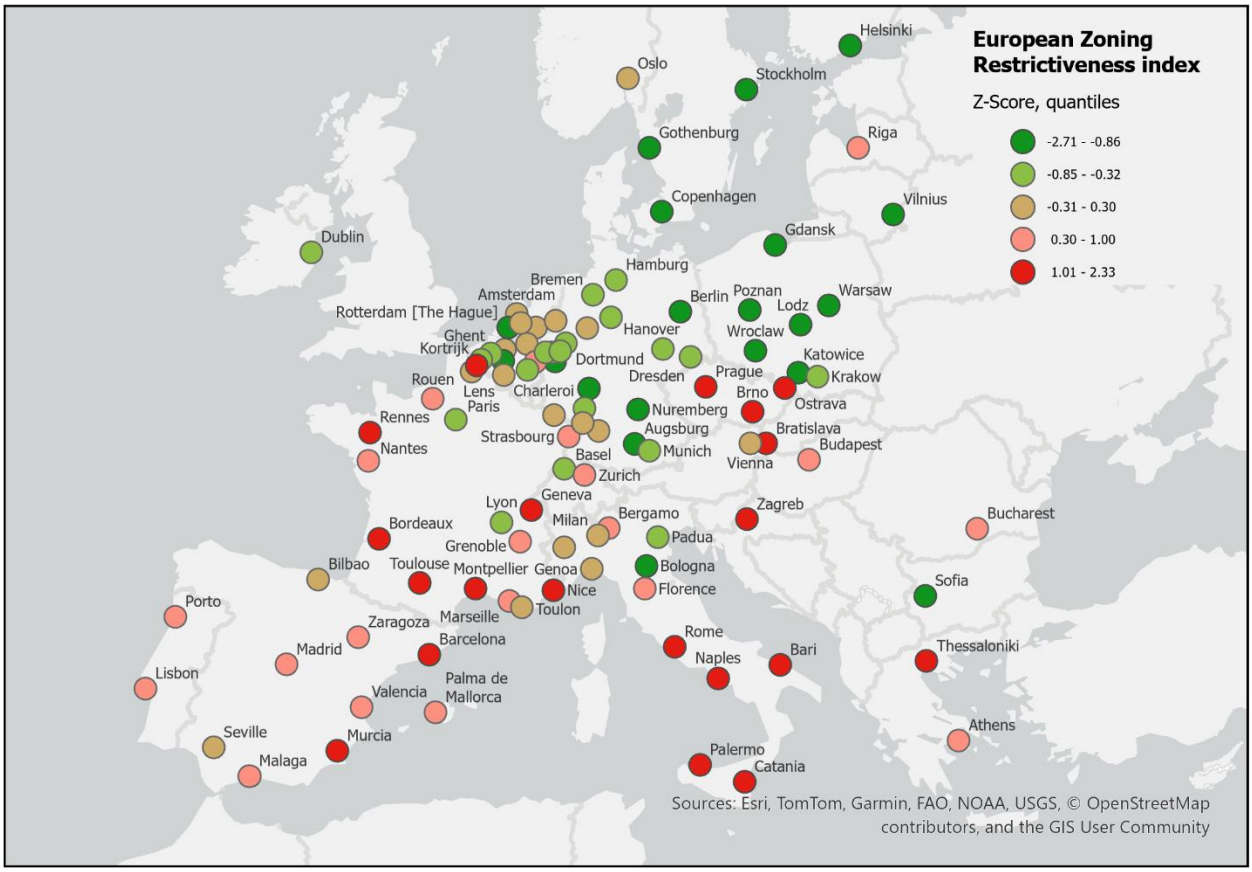
Component 3 is included with negative sign, because its vector is opposite – buildings taller than expected (controlled for population and population change) signifies higher zoning restrictiveness.

In this calculation, each component is given the same weight. We invite researchers to adjust the weights to fit their specific purposes.

Results

The final results of the composite index are presented below, with lower values (green) signifying lower zoning restrictiveness, and higher values the opposite. The results display a strong clustering effect, with southern European countries (Spain, Italy, France, and Portugal) showing higher zoning restrictiveness overall than northern European countries (Belgium, Germany, Sweden, and Poland). Another cluster of zoning restrictiveness can be found in Central and Eastern Europe (the Czech Republic, Slovakia, and Hungary). This spatial codependence of zoning systems is very interesting, but our paper will stop short of interpreting it, as we did not identify sufficiently strong evidence of any cross-national influence in our analysis. It is, however, a promising area for future research.

Figure 2 – Final results – composite index



The results dataset, for both the index overall and for individual components can be found here.

Individual components of our index are not strongly correlated (see the correlation matrix below), with component 1 (number of land-use categories) being positively correlated with the other 3 components, but component 2 (building height) being negatively correlated with component 3 (coefficient of variation change) and component 4 (time and procedures to obtain building permits). This is, to a degree, surprising; at the same time, it illustrates the need for inclusion of various aspects of zoning and, we would argue, illustrates the need for our chosen methodology.

Table 2– Correlation matrix between index components

R	Component 1	Component 2	Component 3	Component 4
Component 1		0.0767	0.0106	0.1581
Component 2	0.0767		-0.1015	-0.1326
Component 3	0.0106	-0.1015		0.1972
Component 4	0.1581	-0.1326	0.1972	

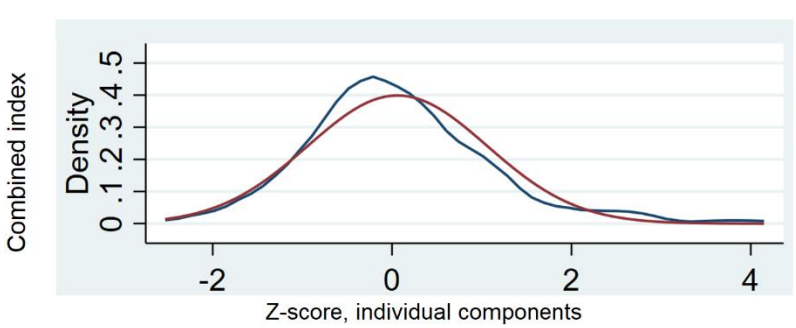
We aspired to provide an index that is regression-ready for use by other researchers. As one of the most pressing features of such an index is the normality of the data, we provide an overview in Figures 3 and 4 below. As with any data, the reality is messy. The final index distribution can be seen on the kernel density below, as compared with the standard normal distribution. While we can't claim the distribution follows the normal distribution (see the results of the normality tests: Shapiro–Wilk, Shapiro–Francia,

Jarque-Bera), real normal distributions are very rare in the real world, and with sufficiently large samples (our N=100), the above-mentioned tests are likely to reject the null hypothesis of the data normality.

This is to be, to a degree, expected. This paper deals with the effects of regulation, and it has been well described by existing literature (Kleven, 2016) that policy introduces kinks, notches, thresholds, or caps, observed distributions frequently develop spikes, heaping, and missing mass instead of remaining smooth. This, in turn, makes the underlying distributions less normal.

This is not a major problem, as non-normal data are often used in regressions. The normality of the input data is only indicative of the normality of the regression residuals, and small deviations are expected, provided robust standard errors are employed.

Figure 3 - Normality of the results – final index

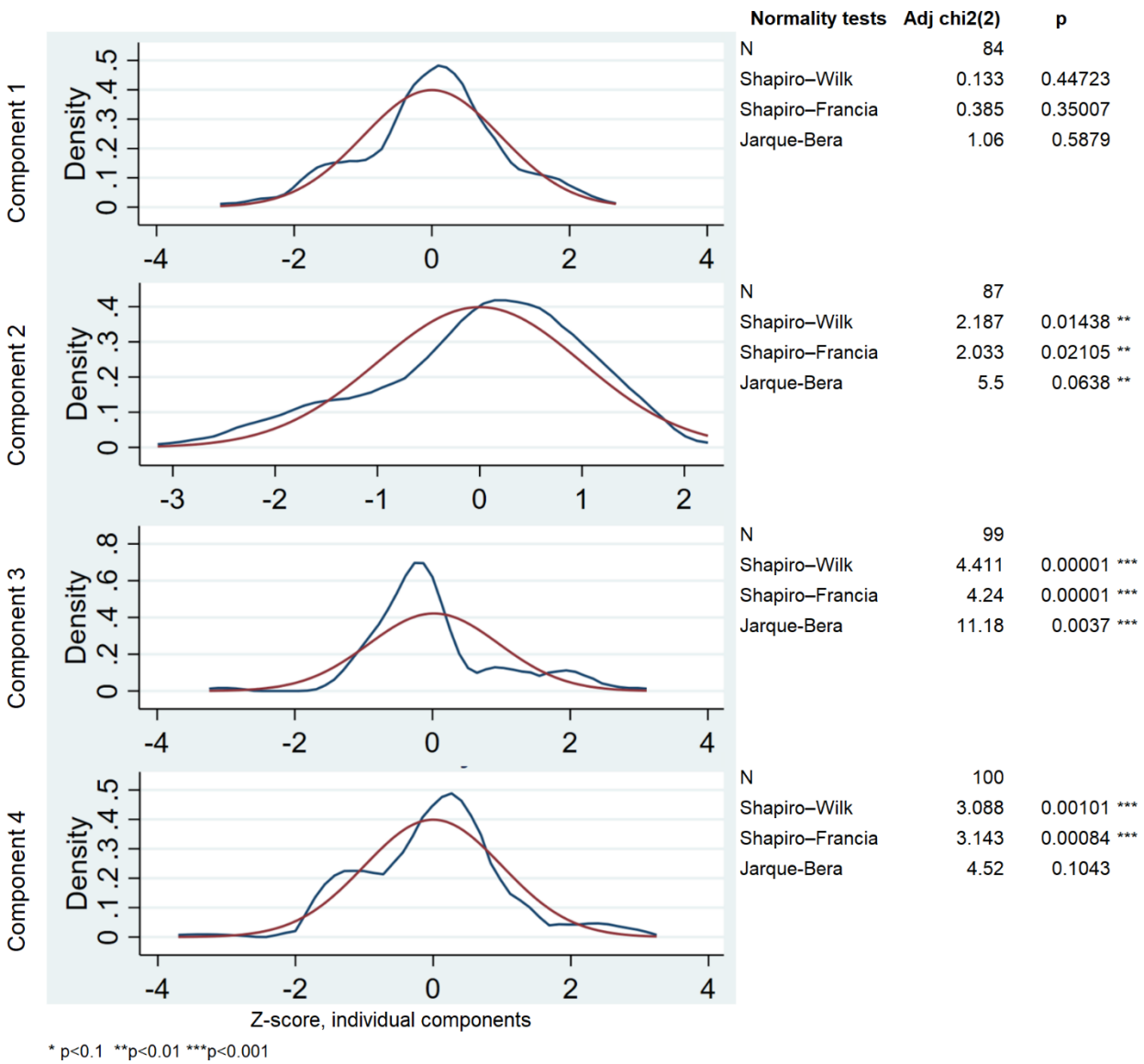


Normality tests	Adj chi2(2)	p
N	100	
Shapiro–Wilk	2.635	0.00421 ***
Shapiro–Francia	2.732	0.00315 ***
Jarque-Bera	13.49	0.0012 ***

* p<0.1 **p<0.01 ***p<0.001

Similarly, we provide the same component 1 (number of land-use categories) passed the normality tests. In the Shapiro–Wilk and Shapiro–Francia tests for normality and the Jarque-Bera test for skew and kurtosis, we did not reject the null hypothesis. For the remaining three components, we did (although for component 2 – building height, only at 90% of significance).

Figure 4 - Normality of the results – individual components



We hope the usefulness of this data for use by other researchers is apparent. Furthermore, the results can and should be used by policy makers as a useful measure of how their cities and metropolitan areas compare to others, and how it affects development. We believe zoning policies should be reformed in many of these municipalities, and this index provides the necessary context. If our measure becomes a frequently referenced benchmark, it has the potential to improve the lives of many people in regards to long commutes, housing affordability and other factors which zoning has been proven to influence.

Cross-validation

Although Europe lacks a single accepted city-level benchmark for zoning restrictiveness, the composite index lines up reasonably well with the case-study evidence that do exist. All three Czech metros in the sample fall in the top 15, with Brno ranked 2nd and Prague 5th, which is consistent with OECD evidence that restrictive land-use governance has contributed to affordability pressures in Czechia (OECD, 2025a). Geneva ranks 12th and Zurich 26th, which fits Swiss survey-based evidence showing that residential-

development stringency predicts refusal rates, as well as OECD assessments that restrictive planning regulations have damped the Swiss housing supply response (Büchler & von Ehrlich, 2023; Vujanovic, 2016).

Spanish results are also broadly consistent with external expectations: all Spanish metros in the sample fall in the upper half of the distribution, with Barcelona ranked 17th. Recent OECD work on Spain points to limited buildable land and slow administrative approvals (OECD, 2025b).

Although these comparisons rely only on a few selected cases, taken together, they suggest that the index is capturing a meaningful common signal of regulatory stringency.

Limitations

This index's methodology is a result of many compromises. First of all, none of the components can be considered a full measure of zoning restrictiveness or even complexity, but only as proxy measures, chosen primarily for being relatively simply quantifiable. We have, however, been very careful to prevent any potential biases.

One aspect which we sincerely regret not including is historical protection, which can impact zoning restrictiveness significantly. This is due to the difficulty of its measurement, as the rules differ significantly among cities and metropolitan areas. That being said, historical protection is often included in zoning plans (component 1) in the form of dedicated zones, and with a special status given to historical landmarks in many cities. This means that historical protection is included, at least partially, in this study.

As stated above, we have not completed the measurement of all 4 components for all 100 FUAs in our sample. Figure 1 – Sample composition, and Table 1 – Index component composition, show that all 4 components were used for the index calculation for 72 FUAs in our sample, 3 were used for 26 FUAs, and only 2 components were used for 2 FUAs (Kortrijk, Belgium, and Catania, Italy). We have considered removing 28 of the "incomplete" FUAs from our sample, but we believe the index overall benefits from their inclusion, if only as comparators for the other FUAs. We have calculated a very simple sensitivity analysis (see Appendix 6), simulating the overall index moves if individual components were removed. As each component measures a different aspect of the zoning regulation or its impacts, the index is sensitive to component omissions – median change of one component omission is 0.33 z-scores, with standard deviation of 0.32 z-scores. We realize the "incomplete" FUAs might give a skewed picture, but we also believe the incomplete data is valuable. But we ask researchers to exercise caution when using data for the "incomplete" FUAs.

Conclusions

This paper presents a new composite index of zoning restrictiveness for 100 large European functional urban areas by combining four measurable dimensions of land-use regulation: land-use-category complexity, realized building height, changes in local population dispersion, and the procedural burden of obtaining construction permits. By bringing these dimensions together in a standardized measure, the paper moves beyond the narrow single-proxy approach that has often been used in European research. The descriptive results point to comparatively higher restrictiveness in many Southern European metros and in parts of Central and Eastern Europe, with lower scores in several Northern and Western European metros in the current sample. The intended use of the index is pragmatic: it is designed as a comparative research input for work on housing supply, affordability, urban form, mobility, and related outcomes, rather than as a stand-alone judgment about whether a city's planning system is normatively desirable.

The index should, however, be interpreted with care. Each component is only a proxy for one aspect of regulation. Important dimensions of regulatory stringency, especially heritage protection and other place-specific constraints, are also only partially captured. For these reasons, the index is best understood as a transparent and extensible starting point for comparative empirical analysis.

List of resources

Ahlfeldt, G. M., & Barr, J. (2022). The economics of skyscrapers: A synthesis. *Journal of Urban Economics, 129*, 103419. https://doi.org/10.1016/j.jue.2021.103419

Alonso, W. (1964). *Location and land use: Toward a general theory of land rent*. Harvard University Press. https://doi.org/10.4159/harvard.9780674730854

ATLAS Collaboration. (2012). Observation of a new particle in the search for the Standard Model Higgs boson with the ATLAS detector at the LHC. *Physics Letters B, 716*(1), 1–29. doi:10.1016/j.physletb.2012.08.020

Archi-Guide. (2024). Grenoble. Retrieved from https://www.archi-guide.com/VL/Fra/grenoble.htm

Baker, D. C., Sipe, N. G., & Gleeson, B. J. (2006). Performance-based planning: Perspectives from the United States, Australia, and New Zealand. *Journal of Planning Education and Research, 25*(4), 396–409. https://doi.org/10.1177/0739456X05283450

Ball, M. (2011). Planning delay and the responsiveness of English housing supply. *Urban Studies, 48*(2), 349–362. https://doi.org/10.1177/0042098010363499

Bayer, P., Ferreira, F., & McMillan, R. (2007). A unified framework for measuring preferences for schools and neighborhoods. *Journal of Political Economy, 115*(4), 588–638. https://doi.org/10.1086/522381

Bayer, P., & McMillan, R. (2012). Tiebout sorting and neighborhood stratification. *Journal of Public Economics, 96*(11–12), 1129–1143. https://doi.org/10.1016/j.jpubeco.2012.02.006

Beck, J., Scott, F., & Yelowitz, A. (2012). Concentration and market structure in local real estate markets. *Real Estate Economics, 40*(3), 422–460. doi:10.1111/j.1540-6229.2011.00322.x

Been, V., Ellen, I. G., Gedal, M., Glaeser, E. L., & McCabe, B. J. (2016). Preserving history or restricting development? The heterogeneous effects of historic districts on local housing markets in New York City. *Journal of Urban Economics, 92*, 16–30. https://doi.org/10.1016/j.jue.2015.12.002

Bertaud, A. (2018). *Order without design: How markets shape cities*. MIT Press.

Bertaud, A., & Brueckner, J. K. (2005). Analyzing building-height restrictions: Predicted impacts and welfare costs. *Regional Science and Urban Economics, 35*(2), 109–125. https://doi.org/10.1016/j.regsciurbeco.2004.02.004.

Brueckner, J. K., Fu, S., Gu, Y., & Zhang, J. (2017). Measuring the stringency of land use regulation: The case of China's building height limits. *The Review of Economics and Statistics, 99*(4), 663–677. https://doi.org/10.1162/REST_a_00650.

Black, S. E. (1999). Do better schools matter? Parental valuation of elementary education. *The Quarterly Journal of Economics, 114*(2), 577–599. https://doi.org/10.1162/003355399556070

Büchler, S., & von Ehrlich, M. (2023). Quantifying land-use regulation and its determinants. *Journal of Economic Geography, 23*(5), 1059–1096. https://doi.org/10.1093/jeg/lbad009

Caldera Sánchez, A., & Johansson, Å. (2013). The price responsiveness of housing supply in OECD countries. *Journal of Housing Economics, 22*(3), 231–249. https://doi.org/10.1016/j.jhe.2013.05.002

Chakraborty, A., Allred, D., & Boyer, R. H. (2013). Zoning restrictiveness and housing foreclosures: Exploring a new link to the subprime mortgage crisis. *Housing Policy Debate, 23*(2), 431–457. doi:10.1080/10511482.2013.764916

Cheung, S. O., Levina, B., & Niu, Y. (2017). Concentration analysis of new private residential units market in Hong Kong. *Construction Economics and Building, 17*(2), 1–23. doi:10.5130/AJCEB.v17i2.5232

Chinco, A., & Mayer, C. (2016). Misinformed speculators and mispricing in the housing market. *Review of Financial Studies, 29*(2), 486–522. doi:10.1093/rfs/hhv061

Choi, H. (2023). Paris, origin of urban modernism. *Urban, Planning and Transport Research, 11*(1), Article 2246541. https://doi.org/10.1080/21650020.2023.2246541

Choumert, J. (2010). An empirical investigation of public choices for green spaces. *Land Use Policy, 27*(4), 1123–1131. doi:10.1016/j.landusepol.2010.03.001

Conejos, S., Langston, C., Chan, E. H. W., & Chew, M. Y. L. (2016). Governance of heritage buildings: Australian regulatory barriers to adaptive reuse. *Building Research & Information, 44*(5–6), 507–519. https://doi.org/10.1080/09613218.2016.1156951 Bond University Research Portal

Coomans, J., & Hermenault, L. (2024). Public works, spatial strategies, and mobility in late medieval Ghent. *Journal of Urban History, 50*(5), 1018–1045. https://doi.org/10.1177/00961442221124892.

Council on Tall Buildings and Urban Habitat. (2024). Explore Data. The Skyscraper Center. Retrieved from https://www.skyscrapercenter.com/explore-data (accessed on 21st May, 2025)

Ding, C. (2013). Building height restrictions, land development and economic costs. *Land Use Policy, 30*(1), 485–495. https://doi.org/10.1016/j.landusepol.2012.04.016

Duranton, G., & Puga, D. (2005). From sectoral to functional urban specialisation. *Journal of Urban Economics, 57*(2), 343–370. doi:10.1016/j.jue.2004.12.002

Ehrlich, M. V., Hilber, C. A. L., & Schöni, O. (2018). Institutional settings and urban sprawl: Evidence from Europe. *Journal of Housing Economics, 42*, 4–18. https://doi.org/10.1016/j.jhe.2017.12.002

Elvery, J. A. (2010). City size and skill intensity. *Regional Science and Urban Economics, 40*(6), 367–379. doi:10.1016/j.regsciurbeco.2010.05.006

Eurostat. (n.d.). *Frequently asked questions (FAQ): Dissemination of European statistics after Brexit*. European Commission. https://ec.europa.eu/eurostat/help/faq#Dissemination%20of%20European%20statistics%20after%20Brexit

Eurostat. (2012, January 23). *GEOSTAT 1 km² population grid (Version 2006)* [Data set]. European Commission, GISCO. Retrieved March 24, 2026, from https://ec.europa.eu/eurostat/web/gisco/geodata/population-distribution/population-grids.

Eurostat. (2023, March 13). *Census population grid (Version 2021)* [Data set]. European Commission, GISCO. Retrieved March 24, 2026, from https://ec.europa.eu/eurostat/web/gisco/geodata/population-distribution/population-grids.

Eurostat. (2024). Geodata: Grids. Retrieved from https://ec.europa.eu/eurostat/web/gisco/geodata/grids

Eurostat. (2024). *Territorial typologies manual – cities, commuting zones and functional urban areas*. European Commission. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Territorial_typologies_manual_-_cities,_commuting_zones_and_functional_urban_areas

Fischel, W. A. (2004). An economic history of zoning and a cure for its exclusionary effects. *Urban Studies, 41*(2), 317–340. https://doi.org/10.1080/0042098032000165271

Frew, T., Baker, D., & Donehue, P. (2016). Performance based planning in Queensland: A case of unintended plan-making outcomes. *Land Use Policy, 50*, 239–251. https://doi.org/10.1016/j.landusepol.2015.10.007

Gant, R. L., Robinson, G. M., & Fazal, S. (2011). Land-use change in the 'edgelands': Policies and pressures in London's rural–urban fringe. *Land Use Policy, 28*(1), 266–279. https://doi.org/10.1016/j.landusepol.2010.06.007

Garde, A., Kim, C., & Tsai, O. (2015). Differences between Miami's form-based code and traditional zoning code in integrating planning principles. *Journal of the American Planning Association, 81*(1), 46–66. https://doi.org/10.1080/01944363.2015.1043137

Gete, P. (2014).*Dealing with construction permits, interest rate shocks and macroeconomic dynamics.* Paper presented at the World Bank Doing Business Conference, Washington, DC.

Geoghegan, J. (2002). The value of open spaces in residential land use. *Land Use Policy, 19*(1), 91–98. doi:10.1016/S0264-8377(01)00040-0

Glaeser, E. L., & Gyourko, J. (2003). The impact of building restrictions on housing affordability. *Economic Policy Review, 9*(2), 21–39. https://www.newyorkfed.org/medialibrary/media/research/epr/03v09n2/0306glae.pdf Federal Reserve Bank of New York

Graefe, A., Armstrong, J. S., Jones, R. J., Jr., & Cuzán, A. G. (2014). Combining forecasts: An application to elections. *International Journal of Forecasting, 30*(1), 43–54. doi:10.1016/j.ijforecast.2013.02.005

Gray, M. N. (2022). *Arbitrary lines: How zoning broke the American city and how to fix it*. Island Press.

Groupe-H. (2024). BIT International Labour Office. Retrieved from https://www.groupe-h.com/en/projects/administrative-buildings/bit-international-labour-office

Gyourko, J., Hartley, J. S., & Krimmel, J. (2021). The local residential land use regulatory environment across U.S. housing markets: Evidence from a new Wharton index. *Journal of Urban Economics, 124*, 103337. doi:10.1016/j.jue.2021.103337

Gyourko, J., Saiz, A., & Summers, A. (2008). A new measure of the local regulatory environment for housing markets: The Wharton Residential Land Use Regulatory Index. *Urban Studies, 45*(3), 693–729. https://doi.org/10.1177/0042098007087341

Hallward-Driemeier, M., & Pritchett, L. (2015). *How business is done in the developing world: Deals versus rules.* Journal of Economic Perspectives, 29(3), 121–140. https://doi.org/10.1257/jep.29.3.121

Han, A. T., & Go, M. H. (2019). Explaining the national variation of land use: A cross-national analysis of greenbelt policy in five countries. *Land Use Policy, 81*, 644–656.

Hilber, C. A. L., & Vermeulen, W. (2016). The impact of supply con straints on house prices in England. *The Economic Journal, 126*(591), 358–405. https://doi.org/10.1111/ecoj.12213

Hirt, S. (2007). The devil is in the definitions: Contrasting American and German approaches to zoning. *Journal of the American Planning Association, 73*(4), 436–450. https://doi.org/10.1080/01944360708978524

Hirt, S. (2013). Form follows function? How America zones. *Planning Practice & Research, 28*(2), 204–230. https://doi.org/10.1080/02697459.2012.692982

Hraška, J. (2019). Approaches, methods and tools of rights of access to sunlight around the world. *Slovak Journal of Civil Engineering, 27*(4), 45–52. doi:10.2478/sjce-2019-0031

Huang, H., & Tang, Y. (2012). Residential land use regulation and the US housing price cycle between 2000 and 2009. *Journal of Urban Economics, 71*(1), 93–99. https://doi.org/10.1016/j.jue.2011.08.001

Hwang, M., & Quigley, J. M. (2006). Economic fundamentals in local housing markets: Evidence from U.S. metropolitan regions. *Journal of Regional Science, 46*(3), 425–453. doi:10.1111/j.1467-9787.2006.00480.x

Ihlanfeldt, K. R. (2007). The effect of land use regulation on housing and land prices. *Journal of Urban Economics, 61*(3), 420–435. https://doi.org/10.1016/j.jue.2006.09.003

Jedwab, R., Barr, J., & Brueckner, J. K. (2022). Cities without skylines: Worldwide building-height gaps and their possible determinants and implications. *Journal of Urban Economics, 132*, 103507. doi:10.1016/j.jue.2022.103507

Jud, G. D., & Winkler, D. T. (2002). The dynamics of metropolitan housing prices. *Journal of Real Estate Research, 23*(1–2), 29–46. doi:10.1080/10835547.2002.12091069

Jun, M.-J., & Bae, C.-H. C. (2000). Estimating the commuting costs of Seoul's Greenbelt. *International Regional Science Review, 23*(3), 300–315. https://doi.org/10.1177/016001700761127416

Kane, T. J., Riegg, S. K., & Staiger, D. O. (2006). School quality, neighborhoods, and housing prices. *American Law and Economics Review, 8*(2), 183–212

Kenety, B. (2019, October 30). *Czechia drops to 157th place in World Bank building permit clearance ranking*. Radio Prague International. Avalable at: https://english.radio.cz/czechia-drops-157th-place-world-bank-building-permit-clearance-ranking-811682 (accessed on 4th August, 2025)

Klement, J., Kozák, J., Ševčík, M., & Pekárek, Š. (2023). Causes of opposition to residential development: A survey-framing experiment from the Czech Republic. *European Planning Studies, 31*(2), 306–327. https://doi.org/10.1080/09654313.2022.2049709

Kleven, H. J. (2016). Bunching. *Annual Review of Economics, 8*, 435–464. doi:10.1146/annurev-economics-080315-015234.

Knowles, R. D., Ferbrache, F., & Nikitas, A. (2020). Transport's historical, contemporary and future role in shaping urban development: Re-evaluating transit oriented development. *Cities, 99*, 102607. https://doi.org/10.1016/j.cities.2020.102607

Korthals Altes, W. K. (2016). Planning reform beyond planning: The debate on an integrated Environment and Planning Act in the Netherlands. *Planning Practice & Research, 31*(4), 420–434. https://doi.org/10.1080/02697459.2016.1198556

Kuang, W., & Wang, Q. (2018). Cultural similarities and housing market linkage: Evidence from OECD countries. *Frontiers of Business Research in China, 12*, Article 10. https://doi.org/10.1186/s11782-018-0030-1

Lawlor, D. A., Tilling, K., & Davey Smith, G. (2016). Triangulation in aetiological epidemiology. *International Journal of Epidemiology, 45*(6), 1866–1886. doi:10.1093/ije/dyw314

Lens, M. C. (2022). Zoning, land use, and the reproduction of urban inequality. *Annual Review of Sociology, 48*(1), 421–439.

Lens, M. C., & Monkkonen, P. (2016). Do strict land use regulations make metropolitan areas more segregated by income? *Journal of the American Planning Association, 82*(1), 6–21. https://doi.org/10.1080/01944363.2015.1111163.

Lerbs, O. W. (2014). House prices, housing development costs, and the supply of new single-family housing in German counties and cities. *Journal of Property Research, 31*(3), 183–210. https://doi.org/10.1080/09599916.2014.893249

Littlefair, P. (2001). Daylight, sunlight and solar gain in the urban environment. *Solar Energy, 70*(3), 177–185. doi:10.1016/S0038-092X(00)00099-2

Lukavec, M., Čáp, V., & Čermáková, K. . (2024). How permitting process length influences development costs and real estate prices. *Economics and Environment*, *89*(2), 768. https://doi.org/10.34659/eis.2024.89.2.768

Mace, A. (2018). The Metropolitan Green Belt, changing an institution. *Progress in Planning, 121*, 1–28. https://doi.org/10.1016/j.progress.2017.01.001

Mageba Group. (2024). WIPO conference hall Geneva. Retrieved from https://www.mageba-group.com/sg/en/1023/Europe/Switzerland/49174/WIPO-conference-hall-Geneva.html

Manville, M., Monkkonen, P., & Lens, M. C. (2020). It's time to end single-family zoning. *Journal of the American Planning Association, 86*(1), 106–112. https://doi.org/10.1080/01944363.2019.1651216

Masschaele, J. (2002). The public space of the marketplace in Medieval England. *Speculum, 77*(2), 383–421. https://doi.org/10.2307/3301326

Mayer, C. J., & Somerville, C. T. (2000). Land use regulation and new construction. *Regional Science and Urban Economics, 30*(6), 639–662. https://doi.org/10.1016/S0166-0462(00)00055-7

Mills, E. S. (1967). An aggregative model of resource allocation in a metropolitan area. *American Economic Review, 57*(2), 197–210.

McConnell, V., Walls, M., & Kopits, E. (2006). Zoning, TDRs, and the density of development. *Journal of Urban Economics, 59*(3), 440–457. https://doi.org/10.1016/j.jue.2005.12.005

McHugh-Russell, L. (2022). Doing Business guidance, legal origins theory, and the politics of governance by knowledge. *Canadian Journal of Development Studies / Revue canadienne d'études du développement, 43*(1), 137–156. https://doi.org/10.1080/02255189.2021.1971953

Mleczko, M., Gold, A., Hu, L., & Mummolo, J. (2023). Using natural language processing to construct a national zoning and land use database. *Urban Studies, 60*(13), 2564–2584. https://doi.org/10.1177/00420980231156352

Muth, R. F. (1969). *Cities and housing: The spatial pattern of urban residential land use*. University of Chicago Press.

Nathanson, C. G., & Zwick, E. (2018). Arrested development: Theory and evidence of supply-side speculation in the housing market. *Journal of Finance, 73*(6), 2587–2633. doi:10.1111/jofi.1271

Neuman, M. (2010). City planning and infrastructure: Once and future partners. *Journal of Planning History, 9*(1), 21–42. https://doi.org/10.1177/1538513209355373.

Oliveira, E., Leuthard, J., & Tobias, S. (2019). Spatial planning instruments for cropland protection in Western European countries. *Land Use Policy, 87*, Article 104031. https://doi.org/10.1016/j.landusepol.2019.104031

OECD. (2025a). *Housing reforms in Czechia and Poland*. OECD Publishing.

OECD. (2025b). *OECD economic surveys: Spain 2025*. OECD Publishing.

Paciorek, A. D. (2013). Supply constraints and housing market dynamics. *Journal of Urban Economics, 77*, 11–26. doi:10.1016/j.jue.2013.04.001

Pendall, R. (1999). Do land-use controls cause sprawl? *Environment and Planning B: Planning and Design, 26*(4), 555–571. https://doi.org/10.1068/b260555

Perrin, C., Nougarèdes, B., Sini, L., Branduini, P., & Salvati, L. (2018). Governance changes in peri-urban farmland protection following decentralisation: A comparison between Montpellier (France) and Rome (Italy). *Land Use Policy, 70*, 535–546. https://doi.org/10.1016/j.landusepol.2017.09.027

Poulos, H.G. Tall building foundations: design methods and applications. *Innov. Infrastruct. Solut.* 1, 10 (2016). https://doi.org/10.1007/s41062-016-0010-2

Pratt, T. C., & Cullen, F. T. (2005). Assessing macro-level predictors and theories of crime: A meta-analysis. *Crime and Justice, 32*, 373–450. https://doi.org/10.1086/655357

Reyerson, K. L. (1997). Public and private space in Medieval Montpellier: The Bon Amic Square. *Journal of Urban History, 24*(1), 3–27.

Rothwell, J. T., & Massey, D. S. (2009). The effect of density zoning on racial segregation in U.S. urban areas. *Urban Affairs Review, 44*(6), 779–806. https://doi.org/10.1177/1078087409334163.

Rubalcaba, L., Gallego, J., Gallo, M. T., & Garrido, R. (2013). Business services location and market factors in major European cities. *Cities, 31*, 258–266. doi:10.1016/j.cities.2012.06.022

Saakjans, D., Kaufmann, D., & Hersperger, A. M. (2026). Scrutinising European land-use planning: Identifying the priorities and goals of building regulations. *Land Use Policy, 164*, 107916. doi:10.1016/j.landusepol.2025.107916

Santaularia, N. J., Ramirez, M. R., Osypuk, T. L., & Mason, S. M. (2022). Economic hardship and violence: A comparison of county-level economic measures in the prediction of violence-related injury. *Journal of Interpersonal Violence*. Advance online publication. https://doi.org/10.1177/08862605221118966

Schilling, J., & Linton, L. S. (2005). The public health roots of zoning: In search of active living's legal genealogy. *American Journal of Preventive Medicine, 28*(2 Suppl. 2), 96–104. https://doi.org/10.1016/j.amepre.2004.10.028.

Schaub, M., & Abadi, F. (2011). Integrated population models: A novel analysis framework for deeper insights into population dynamics. *Journal of Ornithology, 152*(Suppl. 1), 227–237. doi:10.1007/s10336-010-0632-7

Schulze, E. E. (1960). Performance standards in zoning. *Journal of the Air Pollution Control Association, 10*(2), 156–174. https://doi.org/10.1080/00022470.1960.10467915

Shertzer, A., Twinam, T., & Walsh, R. P. (2022). Zoning and segregation in urban economic history. *Regional Science and Urban Economics, 94*, 103652. https://doi.org/10.1016/j.regsciurbeco.2021.103652.

Shirani-Mehr, H., Rothschild, D., Goel, S., & Gelman, A. (2018). Disentangling bias and variance in election polls. *Journal of the American Statistical Association, 113*(522), 607–614. doi:10.1080/01621459.2018.1448823

Short, M. (2007). Assessing the impact of proposals for tall buildings on the built heritage: England's regional cities in the 21st century. *Progress in Planning, 68*(3), 97–199. doi:10.1016/j.progress.2007.07.003

Skyscraper Source Media. (2024). SkyscraperPage. Retrieved from https://skyscraperpage.com/

Somerville, C. T. (1999). The industrial organization of housing supply: Market activity, land supply, and the size of homebuilder firms. *Real Estate Economics, 27*(4), 669–694. doi:10.1111/1540-6229.00788

Strully, K. W., Yang, T.-C., Fang, C., & Liu, H. (2025). Low-density zoning and health disparities in metro areas. *Journal of Health and Social Behavior*. Advance online publication. https://doi.org/10.1177/00221465251391834

Talen, E. (2009). Design by the rules: The historical underpinnings of form-based codes. *Journal of the American Planning Association, 75*(2), 144–160. https://doi.org/10.1080/01944360802686662

Tobias, S., & Price, B. (2020). How effective is spatial planning for cropland protection? An assessment based on land-use scenarios. *Land, 9*(2), 43. https://doi.org/10.3390/land9020043

Urząd m.st. Warszawy. (n.d.). Mapa miejscowych planów zagospodarowania przestrzennego [Interactive map]. Serwis mapowy m.st. Warszawy. Retrieved May 1, 2025, from

https://mapa.um.warszawa.pl/mapaApp1/mapa?service=plany_zagospodarowania

Quigley, J. M., & Raphael, S. (2005). Regulation and the high cost of housing in California. *American Economic Review, 95*(2), 323–328. https://doi.org/10.1257/000282805774670293

Vujanovic, P. (2016). *Policies to tame the housing cycle in Switzerland* (OECD Economics Department Working Papers No. 1279). OECD Publishing.

Weinberg, D. H., Mortonson, M. J., Eisenstein, D. J., Hirata, C., Riess, A. G., & Rozo, E. (2013). Observational probes of cosmic acceleration. *Physics Reports, 530*(2), 87–255. doi:10.1016/j.physrep.2013.05.001

Whittemore, A. H. (2017). The experience of racial and ethnic minorities with zoning in the United States. *Journal of Planning Literature, 32*(1), 16–27. https://doi.org/10.1177/0885412216683671.

World Bank Group. (n.d.1). Dealing with construction permits. Doing Business. Retrieved June 28, 2024, from https://archive.doingbusiness.org/en/data/exploretopics/dealing-with-construction-permits

World Bank Group. (n.d.2). *Methodology: Dealing with construction permits*. In *Ease of Doing Business*. World Bank. https://archive.doingbusiness.org/en/methodology/dealing-with-construction-permits

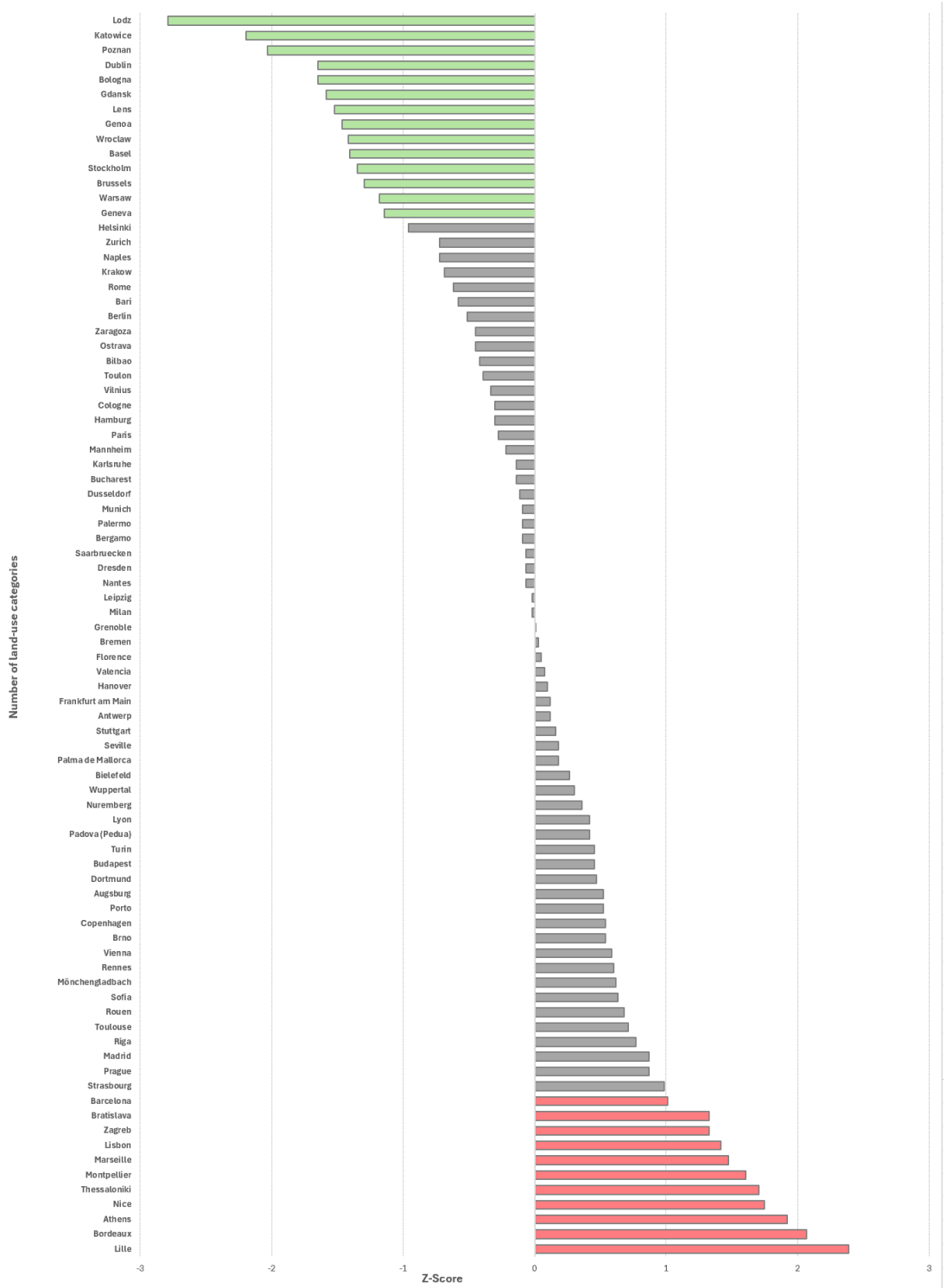
Wrenn, D. H. and Irwin, E. G. (2015). Time is money: An empirical examination of the effects of regulatory delay on residential subdivision development. *Regional Science and Urban Economics, 51*, 77–86. https://doi.org/10.1016/j.regsciurbeco.2014.09.001

Wu, J., & Plantinga, A. J. (2003). The influence of public open space on urban spatial structure. *Journal of Environmental Economics and Management, 46*(2), 288–309. doi:10.1016/S0095-0696(03)00023-8

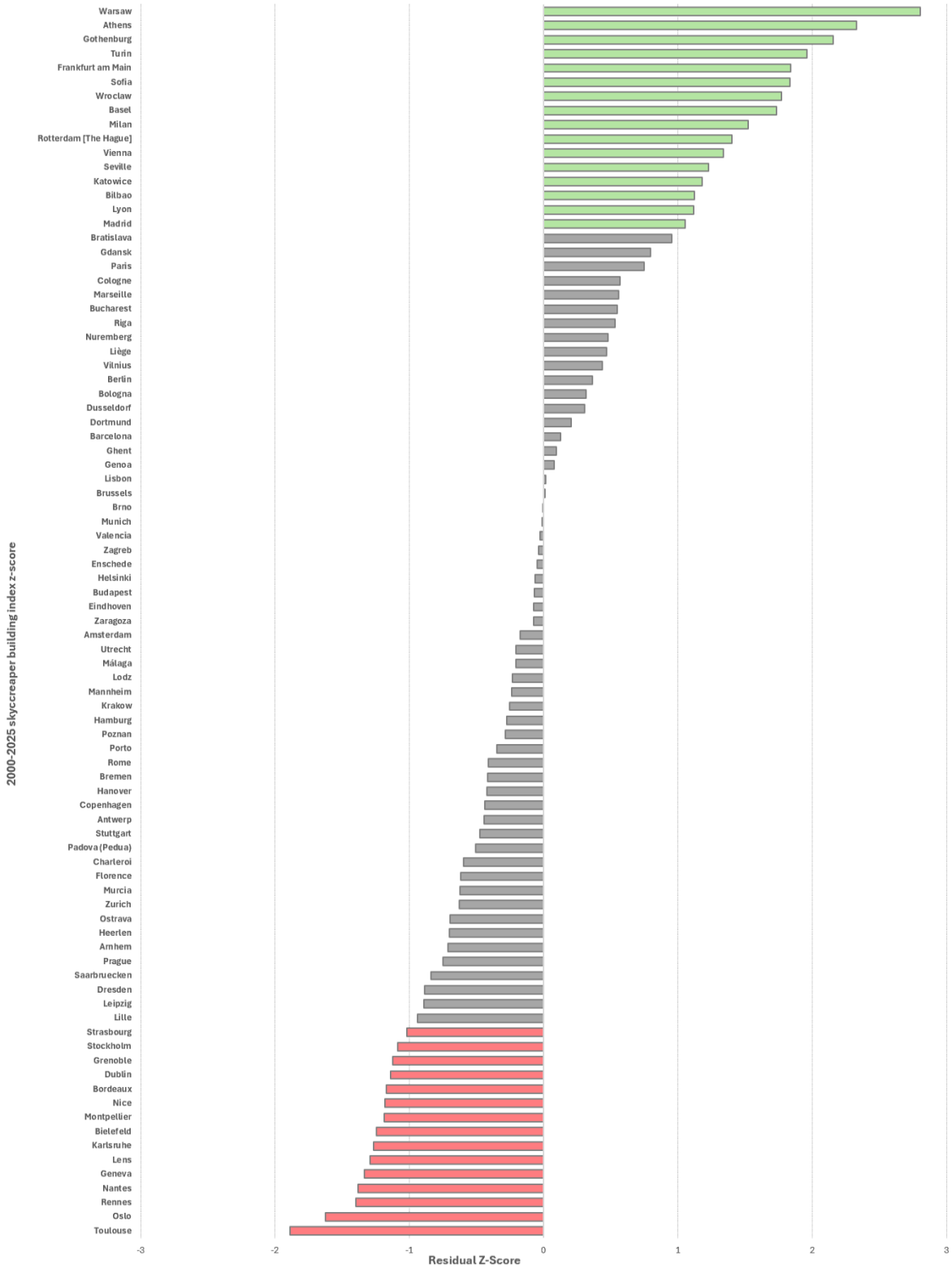
Zheng, X., Xie, X., & Zheng, L. (2023). Land market concentration, developers' pricing decisions, and class monopoly rent in urban China. *Land Use Policy, 132*, 106794. doi:10.1016/j.landusepol.2023.106794

Appendixes

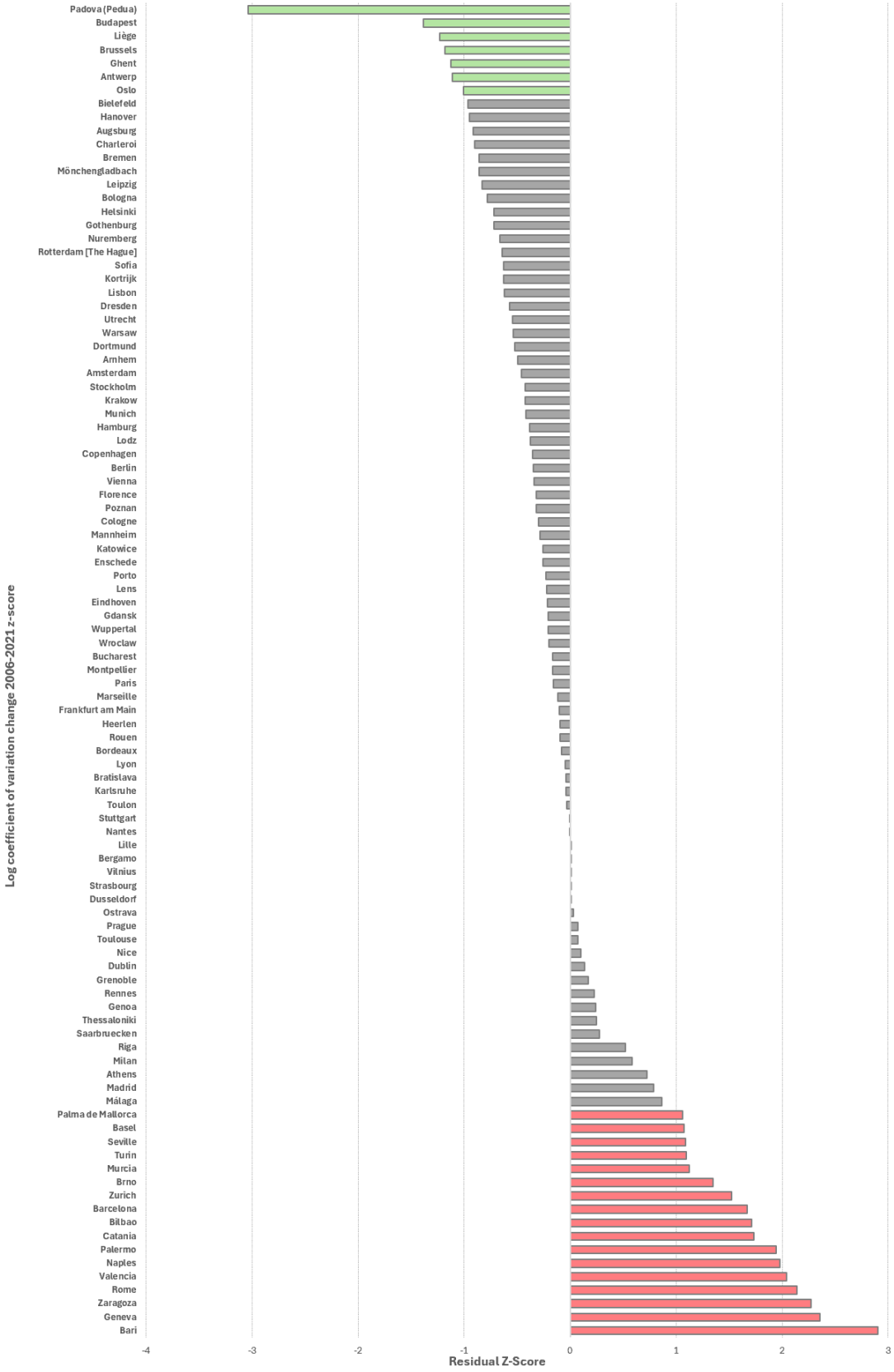
Appendix 1 – Component 1 results



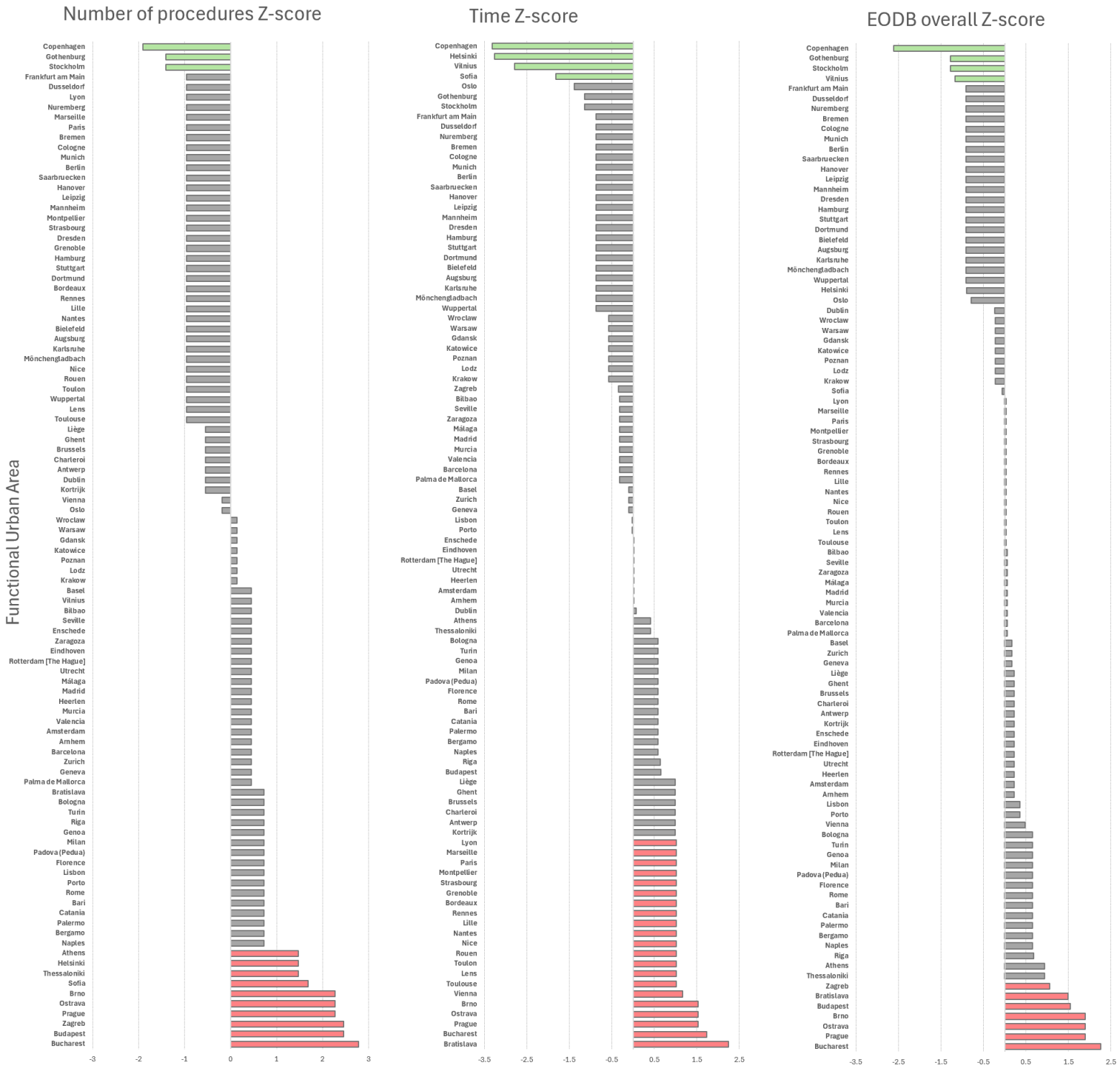
Appendix 2 – Component 2 results



Appendix 3 – Component 3 results



Appendix 4 – Component 4 results



Appendix 5 – Regression Component 2

One outlier in the dataset has been deleted due to its extensive leverage on the regression line:

Figure 5 – Regression

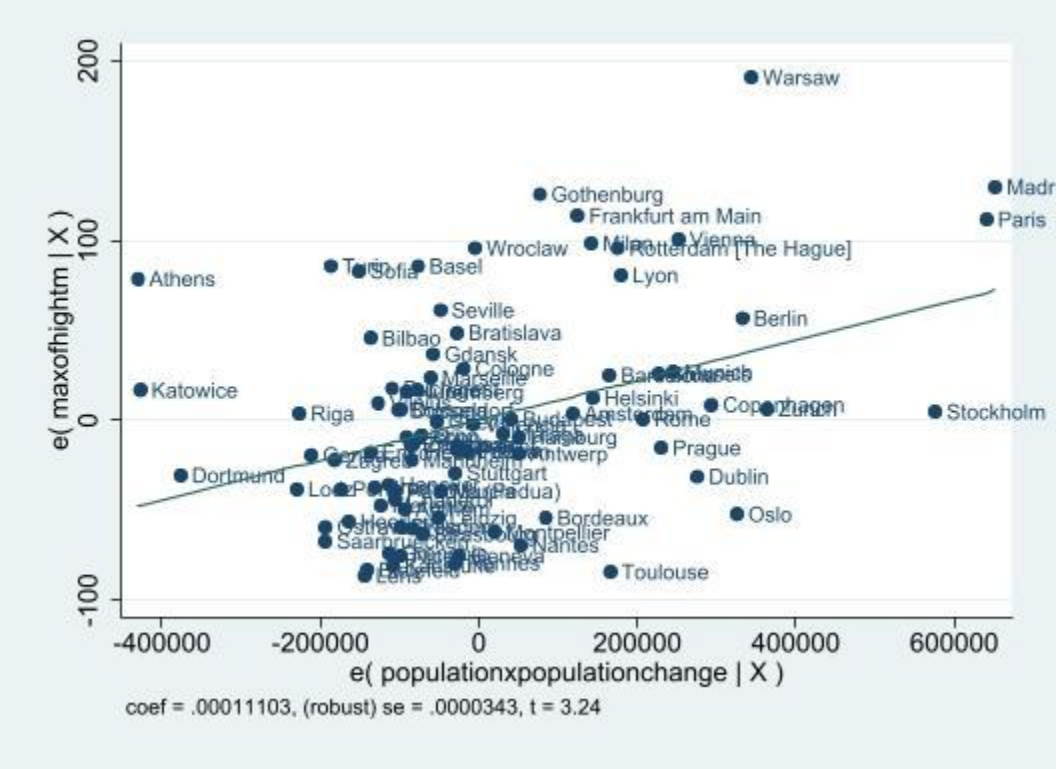


Table 3 – Component 3 regression table

Log of Building Height

	Maximum building height	
Population x Population change	0.0001	**
	(0.0000)	
Intercept	102.3008	***
	(7.4052)	
Observations	87	
R-squared	0.1452	

Robust st. errors in parentheses

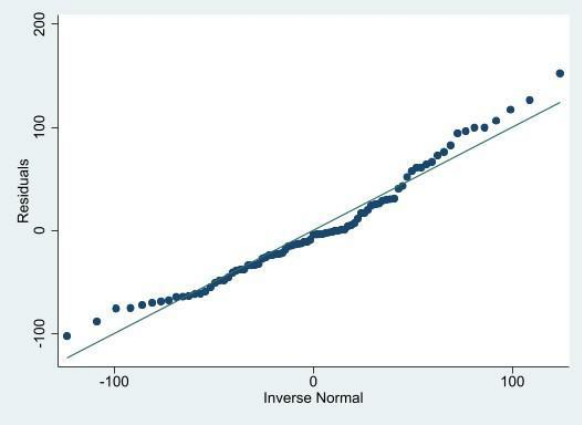
* p<0.1 **p<0.01 ***p<0.001

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

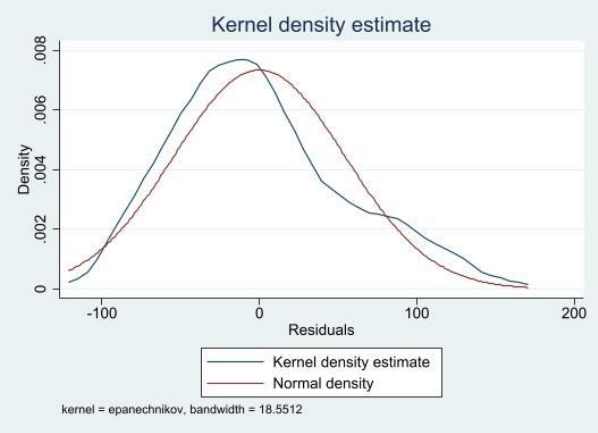
F(1 , 85) = 0.80

Prob > F = 0.3729

Q-Q plot



Kernel density



Appendix 6 – Sensitivity Analysis

	Component 1 removed	*Component 2 removed*	*Component 3 removed*	*Component 4 removed*	*Average across 4 components*
Average absolute index change (z-score)	0.3611	0.3848	0.4054	0.4074	0.3897
Median absolute index change (z-score)	0.2653	0.3178	0.3496	0.3776	0.3276
Standard deviation of the absolute index change (z-score)	0.3379	0.3451	0.3258	0.2818	0.3226