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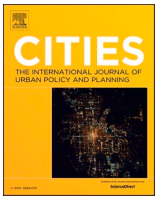

Widening gaps? Socio-spatial inequality in the "very" European city of Vienna since the financial crisis

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ABSTRACT

While European cities were long argued to have moderate levels of socio-spatial inequality, recent years have seen a growing assertion that such inequalities are on the rise. Structural shifts on labor and housing markets since the financial crisis suggest that this trend has further intensified since 2008, but empirical evidence has so far been scarce. This paper examines the case of the "very" European city of Vienna, which, like other European cities, has experienced rising inequality on the labor market and the housing market since the onset of the crisis. Drawing on compound indices, GIS mapping, regression analyses and several inequality metrics as well as a small-scale level of analysis, we demonstrate that socio-spatial inequality has increased in terms of a growing distance between the socio-economic status of spatial units. This is particularly caused by lower status areas that lose ground against the rest of the city. We do not only provide novel empirical evidence on socio-spatial inequality in a major European city after the financial crisis, but also enrich existing methodological frameworks for such an analysis in various ways. The paper concludes with discussing the broader implications of our findings for the debate on socio-spatial inequalities in European cities.

1. Introduction

Socio-spatial inequality is one of the most widely debated issues in urban studies. Most cities in advanced economies have seen a rise of such inequalities in the last decades and research attention to the issue has been considerable (Sassen, 1991; Shi & Dorling, 2020; Tammaru et al., 2016). A relevant part of the literature is devoted to European cities. For a long time, the "European city" model was considered a counter-model to more market-oriented forms of urban development in the United States context (Crouch, 1999), with greater state intervention and comparatively lower degrees of socio-spatial inequality (cf. Fainstein, 1999; Musterd & Ostendorf, 1998; Siebel, 2004). A stronger role played by the welfare state, redistributive local policies, and more comprehensive housing policies were specifically highlighted (Musterd & Ostendorf, 1998; Siebel, 2004). Later contributions have updated this perspective and have argued that also in European cities socio-spatial divisions are growing in the context of economic restructuring, declining welfare states and housing market liberalization (Cassiers & Kesteloot, 2012; Tammaru et al., 2016; van Kempen & Murie, 2009; Zwiers et al., 2015); however, other authors have continued to emphasize the distinct institutional structures and socio-spatial patterns of European cities rather than trends of global convergence (Kazepov, 2005; Le Galès, 2002).

Recent debate relates to the impact of the financial crisis of 2008 (e.g., Knieling & Othengrafen, 2016; Zwiers et al., 2016). The crisis has significantly affected the structural conditions that shape urban development and urban social geographies in cities worldwide, including in Europe. For the latter context, rocketing levels of unemployment (Giannakis & Bruggeman, 2017), an increase in income inequalities (OECD, 2013), as well as a spatially uneven development of urban housing markets have specifically been noted (Zwiers et al., 2016). There is a solid body of literature that addresses these structural shifts and their implications for urban development in different European cities (Andersson & Hedman, 2016; Dijkstra et al., 2015; Ranci et al., 2014). Not least, this literature suggests that the mentioned trends may lead to growing socio-spatial inequalities. There is, however, surprisingly little work that analyzes this empirically (but see Hochstenbach & Musterd, 2018; Knieling & Othengrafen, 2016). This paper addresses this lacuna by analyzing the capital city of Austria: Vienna. We not only provide new empirical insights into socio-spatial inequalities in a major European city after the financial crisis, but also enrich existing methodological frameworks for such an analysis in various ways, as explained

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below.

Vienna is a particularly insightful case to study the recent trajectory of European cities. With a comprehensive national and local welfare state, an exceptionally large decommodified housing stock, and comparably low levels of socio-economic inequality, the city features several characteristics commonly attributed to the European city in a particularly pronounced form, making Vienna a "very" European city. These specific circumstances are also argued to have dampened socio-spatial inequalities in the past (Hatz et al., 2016). However, like other European cities, the financial crisis has impacted Vienna. Rising unemployment, income inequality, and a spatially uneven upgrading of the housing market have become significant features of the city's recent development path. Yet to what extent these changes have led to growing socio-spatial inequalities remains under-researched.

Two concepts are central to our analysis: socio-spatial structure and socio-spatial inequality. The socio-spatial structure concept relates individual level social characteristics to macro level spatial characteristics (at the city or neighborhood level) and reveals how different social groups are distributed spatially (Méndez & Otero, 2018).[1] Social characteristics may include economic capital (household income, goods and services), occupational capital (labor market status), cultural capital (educational level, cultural practices) and social capital (social contacts and networks) (Méndez et al., 2021:1701). The concept of socio-spatial inequality, meanwhile, describes the uneven distribution of social groups in space (following one or more of the social dimensions above) and the resultant unequal distribution of power, wealth and other resources (Marcuse, 2005).

Socio-spatial inequality can be measured in different ways. The urban studies literature typically relies on segregation measures, mapping the residential patterns of different social groups through city-wide segregation indices. In order to widen the methodological toolkit, we instead use a spatial-unit approach more common in economic geography. It focuses on variations in the socio-economic profile or status between different spatial units. Socio-spatial inequality, here, refers to an unequal status of spatial units in an urban area. Drawing inspiration from different literatures, we furthermore refine the spatial unit approach in three ways: First, existing studies have predominantly looked at relative rather than absolute inequalities. We draw on recent arguments from the economic inequality literature and focus on the latter instead. Second, there is a predominant focus on income when measuring the socioeconomic status of spatial units. We agree with the arguments by Boterman et al. (2020) that social status is no longer captured sufficiently by income alone and therefore apply a multidimensional measure that also includes labor market status, social benefit transfers, and educational attainment. Doing so, we thus also use measures of occupational and cultural capital alongside economic capital in measuring socio-spatial inequality for a more nuanced assessment (cf. Méndez et al., 2021:1701). We operationalize these dimensions through average monthly income of employees, share of unemployment, share of social benefit recipients and share of university graduates. Third, in contrast to most other studies, we not only capture changes in the variations of the socioeconomic status between spatial units, but also test for changes in the spatial clustering, i.e., the extent to which the geography of units with a similar/different socioeconomic status changes over time. Taken together, this novel methodological framework provides us with more differentiated insights that existing approaches. We discuss the rationality for our methodological refinements of the spatial unit approach in more detail prior to our analysis.

The study addressed two research questions:

1) **What characterized the socio-spatial structure of Vienna in 2011 and how did it change from 2011 to 2016?**
2) **To what extent is there evidence of increasing socio-spatial inequality over the same period?**

There are two motivations for the choice of our analysis period (2011 to 2016): First, it covers a significant proportion of the time since the financial crisis. It starts late enough, though, that we can expect socio-spatial changes related to changing contextual circumstances to become visible. As Tammaru et al. (2020) show it usually takes some time before structural changes on labor and housing markets affect social geographies. This time-lag effect means that socio-spatial patterns in the early years after the financial crisis will also still reflect structural circumstances from before the crisis to considerable extent. The period 2011 to 2016 is therefore well suited to trace the impacts of the crisis on socio-spatial patterns, even though we do not include a time point from before the crisis. This is especially so as the crisis-related changes on Vienna's labor and housing market also showed a certain time-lag, with both unemployment levels and house prices particularly increasing from 2011 onwards, as we show in the next section. Second, and pragmatically, 2011–2016 is the period for which consistent small-scale data is available. In terms of spatial units, our analysis relies on the particularly small-scale level of census districts, which is an administrative level below the district level in Vienna. Census districts divide the city into 250 entities.

To clarify our contribution: we start from the so far largely untested claim in the literature that structural shifts on labor and housing markets in European cities after the crisis are likely to have led to growing socio-spatial inequalities. We demonstrate that related structural shifts also occurred in Vienna and use the city as a critical case to test the claim. Our focus is thus on the empirical demonstration of the shifting labor and housing market context in Vienna – as potential drivers of growing socio-spatial inequality - and an in-depth investigation of the changes in the city's socio-spatial structure. Moreover, we present an extended methodological framework for such an analysis through the refinement of existing spatial unit approaches. We do not claim that the applied methods are new in themselves. Rather, our contribution is that we amend common approaches in various ways, taking inspiration from different literatures to provide a more differentiated assessment. Taken together, the paper thus contributes to the literature empirically and methodologically.

Our analysis builds on two compound indices, one for capturing the socioeconomic status of each area in Vienna in our base year and one for measuring changes in socioeconomic status. The latter, in accordance with our conceptualization, is based on absolute measures of change. We link the two indices, taking potential nonlinearities, as well as the spatial structure of the underlying data, into account. To gain better insight into the multidimensional development across different socioeconomic status indicators, we analyze the progression of these partial indicators. Finally, we compare our results with traditional inequality metrics, such as various Gini coefficients (standard, intermediate, absolute Gini), the coefficient of variation, standard deviation, the Krtscha measure to test the robustness of our results and the presumed absolute nature of the trend in socio spatial inequality after the financial crisis.

We find that Vienna's social geography was fairly divided in 2011. High-status areas are concentrated in the city center, as well as in the northwest of the city, while low-status areas are concentrated in the south. Socioeconomic status upgrading is similarly concentrated in the center, where the socioeconomic status was already high, while a lot of southern areas, with initially low-status values, faced further downgrading. Overall, the spatial location of high and low-status areas remains stable, meaning that the spatial clustering does not change significantly. A relation of the two indices within a regression framework shows an inverted U-shaped relationship, with particularly low-status areas losing ground against middle and upper class areas. In other words, socio-spatial inequality is growing because lower-status

[1] Méndez and Otero (2018) furthermore distinguish a *meso* level related to territorial stigmatization. This is left out here, however, as it is not taken into account in the analysis.

areas do not keep pace with the socioeconomic status development of other areas. Furthermore, the analysis shows that these patterns are multidimensional and hold across a range of different indicators of socioeconomic status. Comparison with traditional inequality measures confirms both the robustness of our results and the relevance of a perception of inequality by means of absolute measures to capture recent changes in Vienna's social geography.

The remainder of this paper is structured as follows. First, we briefly review the literature on the impact of the financial crisis on socio-spatial inequality. We then demonstrate how Vienna's urban development context has changed since the crisis, identifying structural shifts in the labor and housing market. The next section clarifies how we conceptually enrich existing spatial-unit approaches to analyze socio-spatial inequalities. Then, the methods and data are presented before we turn to our results. In the concluding section, we discuss the broader implications of our findings for the debate on socio-spatial inequalities in European cities.

2. The impact of the Global Financial Crisis on socio-spatial inequality

The drivers and levels of socio-spatial inequality in European cities prior to the Global Financial Crisis have been widely covered and there is thus no need to rehearse this literature (for a review see e.g. Musterd & Ostendorf, 1998; Tammaru et al., 2016). Recent studies focus on developments since then. Zwiers et al. (2016: 666) argue, in an overview article of the impact of the crisis in Global North countries, that it has "contributed to rising inequality (…), particularly in terms of income and housing". The literature highlights three factors:

First, unemployment levels have rocketed since 2008, especially on the lower ranks of the job market. In the EU they have increased by 57 % between 2008 and 2013 alone (Giannakis & Bruggeman, 2017), albeit with considerable regional differences. Second, income inequality and poverty have increased OECD (2013). This was partly caused by labor market changes, partly by austerity programs and social security budget cuts that have minimized the social safety net for vulnerable groups (see Knieling & Othengrafen, 2016 for the rise of new "austerity regimes", specifically in southern-European cities). Third, on the housing market, spending on affordable or social housing has been cut back in many contexts, leaving low-income households with limited options and contributing to a spatial concentration of poverty (Zwiers et al., 2016).

Post-crisis access to housing has meanwhile become increasingly dependent on generational and class position. High house prices have benefited those in home ownership, while making it harder for newcomers and younger people to enter the "property ladder" (Forrest & Hirayama, 2018; Ronald & Kadi, 2018). Housing market access and affordability has in many cases been further complicated by rising investments by institutional investors and private individuals in the private rental market (Aalbers et al., 2021; Kadi et al., 2020), fuelling stock upgrading, rent gap closure and gentrification processes particularly in inner-city neighborhoods. Resultantly, urban housing markets have become more uneven spatially in terms of rent levels, prices and affordability (Hochstenbach & Arundel, 2020). While these transformations have been well underway already prior to the crisis, inter alia driven by market-based housing reforms and privatization measures since the 1980s (Kadi & Ronald, 2014), the Great Recession has in many contexts reinvigorated such policy approaches and related restructuring processes (van Gent & Hochstenbach, 2020), although there have been notable counter-tendencies in some cities recently (Kadi et al., 2021).

According to Zwiers et al. (2016) the growing inequalities on labor and housing markets drive socio-spatial inequalities. The latter "tend to have specific spatial outcomes including segregation [and] increased spatial concentration of low-income groups" (p. 666). This argument follows the common claim that spatial distance reflects social distance (Duncan & Duncan, 1955; Park et al., 1925). There is surprisingly little *empirical* work, however, that analyses this link for the post-crisis context (but see e.g. Ch. 3 in Knieling & Othengrafen (2016)). Andersson and Hedman (2016) investigate crisis-related income inequalities and segregation levels in the Swedish context for the economic crisis in the 1990s and find a correlation between economic recession and income segregation. Hochstenbach and Musterd (2018) examine residential moves of low-income households in the Dutch context in the period 2004–2013. They find a trend toward the suburbanization of poverty driven by housing market exclusion in inner cities, which starts prior to the crisis but continues afterwards, particularly in the Amsterdam context. While these studies provide initial insights into post-crisis developments of socio-spatial inequalities in the European context, more research is needed. Macro-level transformations such as those triggered by the crisis will always be filtered by national and local welfare and housing systems and related institutional landscapes and differ in their impacts across contexts (Musterd et al., 2020). This consequently requires a careful case study focus to disentangle relevant processes in specific institutional contexts. Against this background we now turn to the Vienna case.

3. Vienna: context of a "very" European city in transformation

Vienna is not at the forefront of the debate about rising socio-spatial inequalities in European cities. On the contrary, the city with its 1.8 million inhabitants is often discussed as a case where contextual circumstances have *dampened* them (Hatz, 2009; Hatz et al., 2016; Musterd, 2020; Tammaru et al., 2016)—much in line with the idea of the archetypal "European city." The literature relates moderate levels of socio-spatial inequality in Vienna to its long tradition of Social Democratic governments and policies of social equality—the Social Democratic Party has been in power for the past 100 years, with the only exception being the Nazi period—a comprehensive national and local welfare state, moderate economic restructuring compared to more globalized cities, and a tradition of strong intervention in the housing market (Hatz et al., 2016). Vienna's housing policy is particularly emphasized in the literature with regard to mitigating spatial inequalities. The city has long intervened in the housing market with social housing policies, supported by federal funding and rent regulation. Today, some 44 % of the housing market belongs to the social housing sector, which is owned by either the city or limited-profit housing associations. The sector not only provides below-market rents but is also spread throughout the city, though the concentration is significantly higher in the more peripheral districts, and thus enables lower-income households to reside in areas with higher market rents to certain degree (Kadi, 2015).

The Viennese context has changed considerably since the 1980s, however. The city has undergone marked deindustrialization and a shift toward a more service-dominated economy, with related changes in the occupational structure (Hatz, 2009, p. 488). In the 1990s, Austria entered the EU and Vienna found itself relocated from the fringes to the center of a then unified Europe. In an attempt to position the city as a regional command and control center, the local government has adopted a more entrepreneurial mode of governance (Novy et al., 2001). Meanwhile, restrictive wage policies and rising unemployment on the labor market have contributed to an increase in socioeconomically marginalized groups (Hatz et al., 2016).

These shifts found moderate yet visible expression in the city's social geography. Hatz (2009) analyzed the spatial clustering of different occupational groups between 1981 and 2001. He found a relatively stable pattern overall and no clear trend toward polarization. However, the spatial distances between different groups slightly increased. In a further analysis of the time frame 2001–2010, Hatz et al. (2016) found a more pronounced shift and concluded that there was a slight trend toward spatial polarization, although the changes are limited. Despite this, they contend that socioeconomic features have become more prominent in explaining the city's social geography (Hatz et al., 2016, p. 107).

While these studies are highly relevant to understanding the pre-

crisis context, they do not consider what has happened since then. This constitutes a significant omission, since Vienna, like other European cities, was affected considerably by the financial crisis. To be clear, this is not to say that the specific contextual circumstances of Vienna have faded in the context of a seemingly global convergence, but rather that the city shares recent impacts of the financial crisis with other European cities. Although Vienna was in many ways better protected from such impacts thanks to its relatively protected labor market, limited size of the financial sector, and regulated housing market with a comparatively small mortgage market, both the labor market and the housing market experienced significant changes. In Vienna, these changes were embedded in a pronounced population growth, with the city adding some 180,000 inhabitants (around 10.5 %) between 2010 and 2019 (Stadt Wien, 2020a).

On the labor market, the crisis triggered a considerable rise in unemployment. The unemployment rate, defined as people registered without work (including those in training), rose from 7.9 % in 2008 to 13.6 % in 2016. Change was rather slow in the immediate years after 2008, though, and accelerated from 2011 on. Between 2008 and 2011, unemployment increased by 1.3 % points, between 2011 and 2016 by 4.4 % points (Stadt Wien, 2020b). Meanwhile, income developments particularly for lower-income workers stagnated or declined, an issue intensified by a shift from full-time to temporary work. This did not affect all income groups to the same degree and led to an increase in income inequality. Fig. 1 traces nominal income developments for employees in Vienna (before taxes) between 2008 and 2017. The median income increased by 5.7 %. For the third quartile (75 %), it even increased by 8.9 %. Meanwhile, for the first quartile (25 %), it dropped by 9.2 %, exemplifying more pronounced divides on the labor market.

Considerable changes occurred on the housing market as well. Vienna was very much a “latecomer” to the boom in housing prices in European cities and experienced significant price and rent increases *after* rather than *before* the crisis. Vienna's housing market was “discovered” by institutional and small-time investors as an attractive investment market in the aftermath of 2008 when the housing bubble elsewhere had already collapsed (Springler, 2019). Nominal house prices increased by >70 % between 2008 and 2017, while rents increased by almost 40 %. As with unemployment, rapid house price growth occurred with a certain time-lag and especially took off from 2011 onwards (Fig. 1). Aggregate numbers, however, hide the spatially uneven development of the housing market. To understand this, three points are crucial: First, the two most important housing sectors in Vienna are the social housing sector (44 % of all units) and the private rental sector (33 %). Although a fair share of social housing units is located in more central districts, the sector is generally concentrated in more peripheral districts.[2] Private renting, meanwhile, is concentrated in the central districts. Second, rent developments were highly uneven between the two sectors. Whereas in the social rented sector, rents increased on average by <25 % between 2008 and 2016, in the private rented sector, they increased by >53 % (Tockner, 2017, p. 16). This meant that rents in inner-city districts increased much more quickly. Third, this spatially uneven rent development was further reinforced by so-called location bonuses that private landlords can add on top of the base rent for units in locations with higher land prices since 1994 (Kadi, 2015). With rising land prices, location bonuses have rocketed. In the city center, the first district, for example, they went up from €4 per square meter in 2010 to €11 in 2017. Generally, location bonuses increased most in areas that already had high bonuses in 2010 and vice versa, promoting growing rent differentials between areas in the city (Kadi, 2015). Finally, this development was reinforced by the spatially uneven rent development of new housing construction. With rising land prices, social housing providers, who build more inexpensive units than commercial providers, had increasing difficulties finding affordable land in central districts and thus increasingly shifted the provision to peripheral districts. Higher-priced construction by commercial providers, meanwhile, took place in the more central areas. Taken together, these developments promoted a spatially highly uneven development of the city's housing market, with significantly higher rent increases in the inner-city districts compared to more peripheral areas.

As discussed, higher levels of socioeconomic inequality lead to higher levels of socio-spatial inequality, based on the fact that spatial distance tends to follow social distance (Duncan & Duncan, 1955; Park et al., 1925; Tammaru et al., 2016). Meanwhile, we know from previous analyses that a spatially uneven upgrading of the housing market reinforces the link between labor market outcomes and housing positions and promotes greater spatial divisions along the lines of class, wealth, and occupational structure (Musterd et al., 2020; van Gent et al., 2019). Recent changes on Vienna's labor and housing markets related to growing socioeconomic divides on the one hand and an uneven housing market development on the other thus suggest that socio-spatial inequalities in the city have become more pronounced in the context of the structural changes that have occurred since the onset of the financial crisis. The empirical analysis will test this hypothesis.

4. Amending the spatial-unit approach to analyze socio-spatial inequalities

Our analysis draws on established procedures in the spatial-unit approach to analyze socio-spatial inequalities. We refine this approach, however, related to three questions that are central to any analysis of socio-spatial inequality. The first is how inequality is conceptualized and thus measured. Typical measures of socio-spatial inequality in a spatial-unit approach draw on indices such as the Gini index. Based on spatialized aggregate data, it would be easy to calculate an index value and track its development over time to assess trends in socio-spatial inequality. Examples covering Vienna can be found in Marcińczak et al. (2016) or Moser and Schnetzer (2017).

What characterizes such a popular inequality measure is its relative nature. Overall inequality is deemed stable if all units present the same growth rate. However, what such a measure misses, is that similar growth rates will translate into significant differences in absolute gains at different ends of the distribution. Thus, relative measures have some problematic implications as pointedly summarized by Harvey (2019):

> Would you rather have a 10% rate of return on $100 or a 5% rate of return on $10M? Now, clearly the 5% rate of return on $10M is going to outweigh, immensely, the rate. So, we should be thinking more seriously about the mass as a way in which inequality can be developed at the same time as it can appear as if inequality is being reduced.

The macroeconomic literature on global income inequality has already acknowledged the relevance of this notion and is increasingly also considering absolute inequality measures, thereby sparking a debate also relevant to other fields (for a discussion, see Atkinson & Brandolini, 2010; Niño-Zarazúa et al., 2017; Ravallion, 2003). Such absolute measures see a similar absolute unit increase (rather than a similar growth rate) over the whole distribution to be keeping the level of inequality stable. At least when discussing income (Atkinson & Brandolini, 2010; Bosmans et al., 2014; Niño-Zarazúa et al., 2017), wealth (Boserup et al., 2016), or health (Harper et al., 2010), absolute inequality measures are becoming more widely-used. In the absence of a general rule about what would be the right approach, for this study we decided to consider socio-spatial inequality in Vienna in absolute terms for two reasons: First, as the concept of absolute inequality is based upon absolute differences between the observed units, it very much fits the idea of widening or narrowing gaps in society. Second, there is an unjustified absence of absolute inequality measures in the current literature on socio-spatial

[2] The share of social housing in the inner districts (districts 1 to 9) is on average 20.3 %. In the outer districts (10–23), it is 41.9 % (Statistics Austria, 2011).

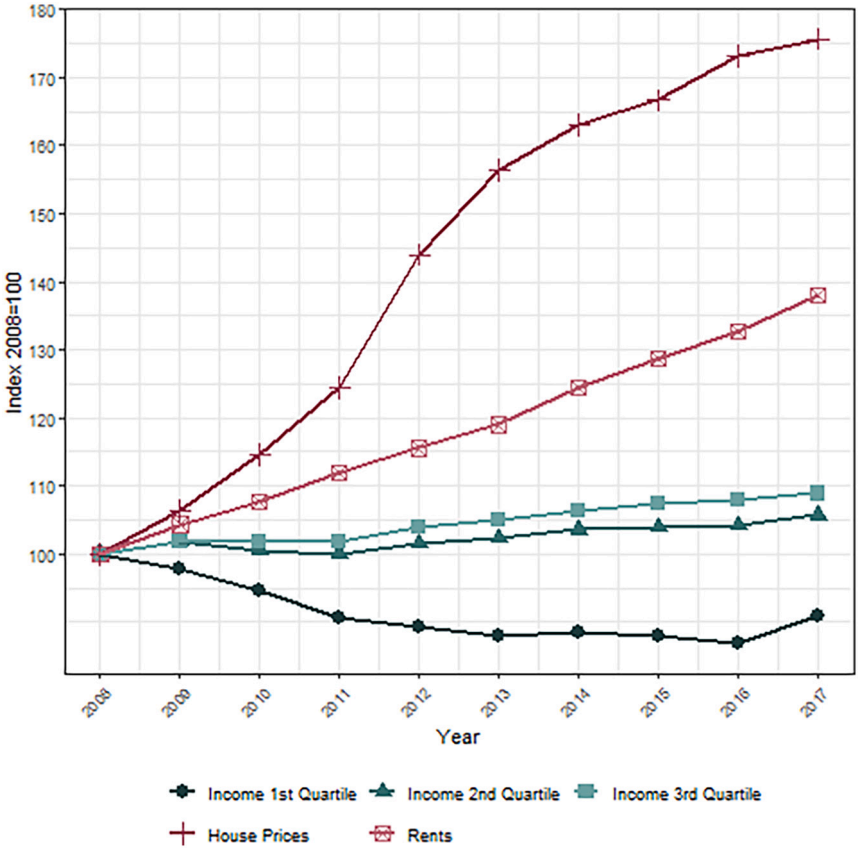

Fig. 1. Income, house price and rent developments in Vienna, 2008–2017.
Source: own depiction based on Statistics Austria (2019) for rents, Oesterreichische Nationalbank (2019) for house prices and Statistics Austria (2010, 2012, 2014, 2016, 2018) for incomes. Note: 2008 = 100, income quartiles based on wage tax statistics, rents and purchase prices are €/square meter.

inequality in general and socio-spatial inequality in Vienna in particular.

The second conceptual question is how the social dimension of socio-spatial inequality is conceptualized and measured. When the focus is on the socio*economic* status of spatial units, the focus is typically on income. We follow the literature in doing so but amend it to arrive at a more comprehensive picture of the socioeconomic status of households in a spatial unit. Specifically, we also include labor market status and educational attainment. Additionally, we include the level of social benefit recipients, as an indication of both poverty levels and household dependence on the welfare state. We combine these dimensions in an aggregate social status measure and also consider them separately as partial indicators.

Our main argument for using this wider set of dimensions, rather than solely income, to measure the socioeconomic status of households in an area is that, in our view, it better reflects the significant degree to which the socioeconomic status of households, besides income, is determined by other factors such as labor market status, social benefit status, and educational attainment. As Boterman et al. (2020) argue, these factors have now become additional fault lines of social differentiation and there is thus a need for a multidimensional assessment of socioeconomic status when measuring socio-spatial inequality in order to arrive at a more nuanced assessment.[3]

The third question is how the matter of space is dealt with in the analysis. The primary focus in the spatial-unit approach is on the variation in socioeconomic status between spatial units and how it changes over time, regardless of *where* these units are located and how the geography of units with different socioeconomic status changes. There is a distinct section of literature that specifically looks at the spatial clustering of units and whether/to what extent similar units adjoin one another (Morril, 1991; White, 1983; Yao et al., 2019). According to Shi and Dorling (2020), a combination of both approaches is, so far, rather rare. In order to arrive at a more complete picture, we therefore also include the dimension of spatial clustering in our analysis.

5. Research approach, methods, and data

To recapitulate, we analyze Vienna's socio-spatial structure and changes therein between 2011 and 2016 on the small-scale spatial level of census districts to answer two research questions: (1) What was the socio-spatial structure of Vienna in 2011 and how did it change from 2011 to 2016? (2) To what extent is there evidence of increasing socio-spatial inequality over the same period? To answer these questions, we develop a three-step analytical framework.

For the first question, we construct a measure of the socioeconomic status of each spatial unit in our base year, 2011. We do so by means of an index of a weighted average of standardized variables[4] that represent different spheres of household socioeconomic status in an area. We use (1) average monthly net income of employees, (2) share of university graduates, (3) share of unemployment, and (4) share of social benefit recipients, with the latter two given half the weight as both

[3] Importantly, we do not include ethnicity, as the socioeconomic status of people with migration background varies considerably in Vienna.

[4] We use the population-weighted average for standardization to allow for interpretations as being relative to the city average.

unemployment and receipt of social benefits are strongly linked and represent a joint dimension of labor market exclusion.[5] The weighted average is then divided by its standard deviation for standardization. Values above zero indicate an above citywide average socioeconomic status and vice versa. We will refer to the 2011 base year index as the Socioeconomic Status Index (SSI).

In a second step, we develop a measure to capture changes in the socioeconomic status of our spatial units, the Social Change Index (SCI). Building on our conceptual framework of analyzing absolute socio-spatial inequalities, we assess the level of absolute change in the four partial indicators compared to the citywide development. If the partial indicator upgrading of a single unit corresponds to the citywide trend of the respective dimension, there is no change in status. Hence, if all units fulfilled the naive expectation of matching the citywide development, there would be no change in absolute status inequality. Mathematically speaking, status upgrading of the partial indicators is defined as follows:

$$y_{ij} = sd\left(x_{ijt+1} - E\left(x_{ijt+1}\right)\right)$$

where y_{ij} is the standardized partial upgrading indicator of dimension j for unit i, x_{ijt+1} is the respective status indicator at time t_{+1}, and $E(x_{ijt+1})$ is its expected value if it follows the citywide trend, thus:

$$E\left(x_{ijt+1}\right) = x_{ijt} + \sum_i wgt_i x_{ijt+1} - \sum wgt_i x_{ijt} = x_{ijt} + \Delta x_j^{city}$$

where wgt_i is the weight used for the mean calculation—in our case the population share of the spatial unit—and Δx_j^{city} is the citywide change in x_j.

Some reformulation then yields

$$y_{ij} = sd\left(\Delta x_{ij} - \Delta x_j^{city}\right)$$

The compound indicator of status upgrading is, as for the SSI above, the weighted average of the j partial indicator developments y_{ij}. We refer to this as the Social Change Index (SCI).

Due to the spatial nature of our data, we are not solely interested in the variation of our index values but also in their distribution in space. Hence, we want to have some quantification of the spatial dependencies in the data, i.e., by measuring the degree of cluster formation regarding both high and low-status units. A well-known, global measure of spatial dependency is the Moran's I statistic, which is defined as

$$I = \frac{N}{\sum_i \sum_j w_{ij}} \frac{\sum_i \sum_j w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_i (x_i - \bar{x})^2}$$

where w_{ij} is an element of a row-standardized spatial weights matrix.[6] The Moran's I statistic is defined between −1 and 1, with the extreme values suggesting either perfectly dispersed data or perfect clustering. Values around zero imply spatially random data distribution. However, a global statistic such as this is limited in that it ignores hot and cold spots of cluster formation. For this reason, we also look at the corresponding local measure of spatial dependency, the Local Moran's I statistic, introduced by Anselin (1995). It can be used to detect heterogeneous patterns of spatial autocorrelation, as cluster formation might not be a stationary phenomenon. Mathematically, the Local Moran's I is defined as

$$I_i = \frac{N(x_i - \bar{x})}{\sum_i (x_i - \bar{x})} \sum_j w_{ij}\left(x_j - \bar{x}\right)$$

[5] As a higher quantity of unemployment and social benefit recipients represents a lower socioeconomic status, these values are multiplied by −1 before being standardized.

[6] We define W using a k-nearest neighbors algorithm with k = 5. However, robustness checks show that our results are not sensitive to the exact specification of W.

The third step addresses our second question, i.e., whether there is evidence of growing socio-spatial inequality over our period of investigation. We do so by relating the Socioeconomic Status Index (SSI) to the Social Change Index (SCI). The idea is rather straightforward – if higher initial status is associated to higher upward status changes socioeconomic status diverges across the city, i.e. inequality rises. An empirical test could simply be achieved by looking at the correlation of both indices. We, however, choose a more sophisticated approach to better deal with potential nonlinearities and the spatial structure of the data. Thus, we relate both measures within a linear regression framework, trying to explain the up- or downgrading of social status compared to the initial status levels of 2011. In doing so, we test the hypothesis of increasing socio-spatial inequality over time. A positive relationship over the whole domain would indicate growing socioeconomic divergence in absolute terms, as higher-status areas would have higher expected status increases (or at least lower decreases), with the opposite holding true for low-status areas. However, we are not only interested in the estimated regression coefficients themselves, but also in the fitted values. Positive expected values on a given initial status level imply upgrading of socioeconomic status, while negative expected values imply downgrading. Econometrically speaking, we are estimating

$$SCI = \alpha + \beta_1 SSI + \epsilon \quad (1)$$

by Ordinary Least Squares (OLS). Here, the sign β_1 gives us an estimate of whether the degree of upgrading, as measured by the SCI, rises (positive) or declines (negative) with higher socioeconomic status, as measured by the SSI. Further, the absolute value of β_1 gives us the impact of a one-unit change in initial status upon socioeconomic upgrading of a spatial unit, assuming the same relationship holds for all units. Moreover, we also check for a potential nonlinear relationship by allowing for different effects of changes to the initial status on the SCI depending on the level of the initial status. We therefore additionally incorporate a squared term into the regression equation:

$$SCI = \alpha + \beta_1 SSI + \beta_2 SSI^2 + \epsilon \quad (2)$$

Now a positive coefficient β_2 implies an increasing marginal effect of initial status on upgrading and a negative coefficient suggests decreasing effects.

A common concern when dealing with spatial data is that the observations are not independent but exhibit spatial dependency (Anselin, 2013; LeSage & Pace, 2009). We thus further solidify our analysis by controlling for potential spatial spillovers by replacing our initial OLS model with a Spatial Autoregressive (SAR) model with a spatially lagged dependent variable, therefore combating biases stemming from a potential breach of the independent observations assumption:

$$SCI_i = \rho \sum_j w_{ij} SCI_j + \alpha + \beta_1 SSI_i + \beta_2 SSI_i^2 + \epsilon_i \quad (3)$$

Practically speaking, this means that social status upgrading measured by the SCI of a spatial unit, has a spillover effect onto its neighboring units, which then in turn affect their respective neighbors and so on. Also from a theoretical perspective this is quite plausible – socioeconomic upgrading of a given neighborhood might also spark developments within its neighborhood and vice versa. In contrast to the aforementioned models, the SAR model can no longer be estimated by Ordinary Least Squares due to its non-linearizable nature. We therefore turn to a maximum likelihood (ML) estimator. Model two and three both show unit-specific first derivatives with respect to initial social status. By looking at those derivatives, we can gain insights into the variation in expected upgrading expectations of an external shock to the SSI, for instance through a policy measure, large investment project, or some kind of planning measure.

To evaluate our general results on a more disaggregated level, we continue by investigating the partial indicators separately. We are aware of the argument that the socioeconomic dimensions we include in our

two indices (income, employment status, social benefit status, education level) are related to some extent. We could have therefore also proceeded with a simpler, one-dimensional index that solely focuses on one dimension, e.g. income. Our argument for a multi-dimensional index is that we are interested in capturing socioeconomic status and change across related, yet different dimensions for a more comprehensive picture. By considering the partial indicators also separately, we want to make sure that our results are neither driven by single partial indicators nor outliers in the data. Thus, we assign each area to an SSI quintile and plot the distribution of SCI, as well as partial change indicators, by SSI quintile.

Finally, we verify our outcomes regarding the absolute nature of socio-spatial inequality trends in Vienna after the financial crisis by comparing them in each partial indicator of the SSI to results obtained by more traditional measures of inequality. We thus compute several statistics of relative, absolute, and intermediate (combining both absolute and relative aspects) inequality suggested by Niño-Zarazúa et al. (2017) and track their yearly development between 2011 and 2016. We expect that at least the trend of the respective absolute inequality measures and to some extent the intermediate measures correspond to the findings based on the methodology described above.

We start with the very well-known Gini coefficient (G) of the rank-ordered data so that $x_i \leq x_i + 1$ for all i in $\{1, \ldots n\text{-}1\}$:

$$G(x) = 1 - \sum_i (pop_i - pop_{i-1})(x_i + x_{i-1})$$

where pop_i is the cumulated proportion of the population variable up to unit i and x_i is the respective cumulated proportion of the indicator variable. While the classical Gini coefficient is a measure of relative inequality, its absolute counterpart is the accordingly named Absolute Gini (AG), defined as:

$$AG(x) = \bar{x}G(x)$$

while following Subramanian and Jayaraj (2013), an intermediate measure (IG) can be expressed as the product of the relative and the absolute Gini coefficients:

$$IG(x) = G(x)AG(x)$$

In addition to the Gini indices, we also use a group of measures that are based on the variance of the data. First, the relative inequality level can be captured by the coefficient of variation (CV), defined as the standard deviation by the mean of the data:

$$CV(x) = \frac{SD(x)}{\bar{x}}$$

A much better-known absolute measure is Standard Deviation (SD) itself:

$$SD(x) = \sqrt{var(x)}$$

Another intermediate measure can then be constructed as the product of the former, known as the Krtscha measure (K):

$$K(x) = CV(x)SD(x)$$

To summarize, we construct two indices, one of the socioeconomic status of each area and one of the change in this status. We then formally test whether there is a positive relation between status and upgrading which would imply an increase in socio-spatial inequality. We therefore run four separate regressions to link both indices. Lastly, we conduct two robustness checks regarding the multidimensionality and the absolute nature of socio-spatial inequality developments in Vienna after the financial crisis. This is done by looking at the behavior of our partial indicators on a disaggregated level and by tracking the development of their concentration using several common inequality measures.

Our data stem from the annual Register-based Labor Market Statistics (*Abgestimmte Erwerbsstatistik*), the Wage Tax Statistics (*Lohnsteuerstatistik*), and the Subsistence Payment Statistic statistics (*Mindestsicherungsstatistik*) and were provided by the national Statistics Austria institute and the City of Vienna. Each dataset is available in a consistent form for the years 2011 to 2016.

Our spatial unit of analysis, census districts (known in German as *Zählbezirke*), have an average number of 8000 inhabitants (2016), enabling small-scale observation. Over our analysis period, there were no changes in the borders of the 250 census districts. Twelve districts had to be excluded, as data points were missing. Due to a low number of residents living there, this, however, does not significantly impact our overall analysis.

Fig. 2 provides a geographical overview of Vienna's census districts. It also includes several geographical features of the city that will be used for the interpretation of the results: two major roadways, the Ring, which encircles the city center (the so-called 1st district), and the Gürtel, which separates the inner districts from the outer districts, and the sections of the River Danube, which divide Vienna into Cisdanubia (on this side of the Danube) and Transdanubia (on the other side of the Danube). Excluded *Zählbezirke* (see above) are depicted with a white dashed line pattern.

6. Results

6.1. What characterized the socio-spatial structure of Vienna in 2011 and how did it change from 2011 to 2016?

Vienna's social geography was fairly divided between lower and higher-social status neighborhoods in 2011. Neighborhoods with the highest status are in the inner-city districts within the Gürtel, with almost all neighborhoods in the top 40 % in the citywide distribution (red and dark red on the map in Fig. 3). In the city center, within the Ring, social status is particularly high, with all neighborhoods within the top 20 % (dark red). Further higher-status neighborhoods are located in the outer areas in the west and northwest of the city, as well as in the southeast.

By contrast, lower-status neighborhoods are notably located around the Gürtel, forming a doughnut-like structure of low-status neighborhoods around the higher-status inner-city neighborhoods. There is a small gap in this structure in the northwest of the inner city, where higher-status neighborhoods prevail. Neighborhoods with the lowest social status (bottom 20 % of the citywide distribution) are located to the south and southeast of the inner city. Comparing the social geography south and north of the Danube, the north, also known as Transdanubia, generally shows a more heterogeneous pattern than the south (Cisdanubia). The Moran's I statistic can provide some quantification of the degree of cluster formation regarding both high and low-status units. A coefficient of I = 0.54, which is significant at the 0.1 % level confirms the notion of spatial clustering of neighborhoods in similar social status categories. The left side of Fig. 4 shows the statistically significant SSI clusters based on the Local I statistic. High-High clusters are identified in in the inner city, the northwest, the southwest, and south. Meanwhile, Low-Low clusters are found south and southwest of the Gürtel as well as in the north on both sides of the Danube. Interestingly, no significant High-Low or Low-High clusters were detected. This does not only confirm the previous eye test of Fig. 3 but also suggest that the global spatial autocorrelation measured by the Moran's I is not fully reflective of the level of spatial autocorrelation in the hotspots identified in Fig. 4.

How did the socio-spatial structure of the city change between 2011 and 2016? The analysis shows a fairly clear pattern, although somewhat less clear-cut than the pattern of the socio-spatial structure in 2011 (see Fig. 3 on the right). There is a relative status increase within the Gürtel, with almost all neighborhoods part of the fourth or fifth quintile of status change (red and dark red on the map). Within the Ring almost all neighborhoods are in the top fifth quintile. There is a relative decline around the Gürtel, in the west, and particularly south of the inner city. A circle of neighborhood decline around the inner city is detectable,

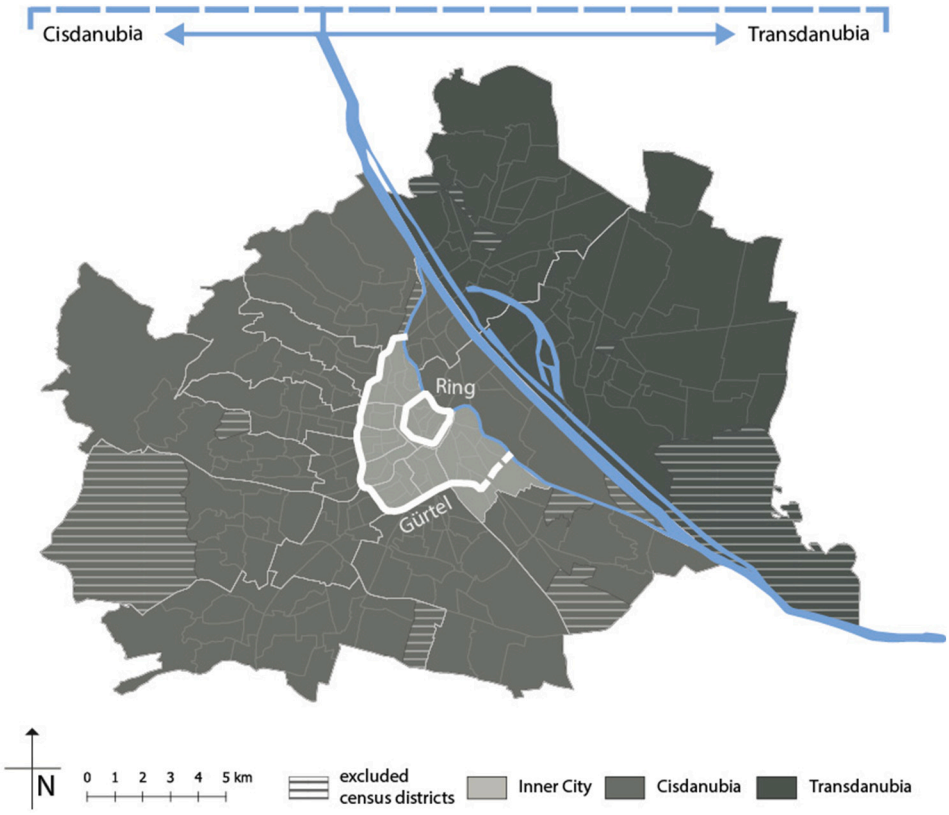

Fig. 2. Census districts (*Zählbezirke*) and major geographic features in Vienna.
Source: own depiction.

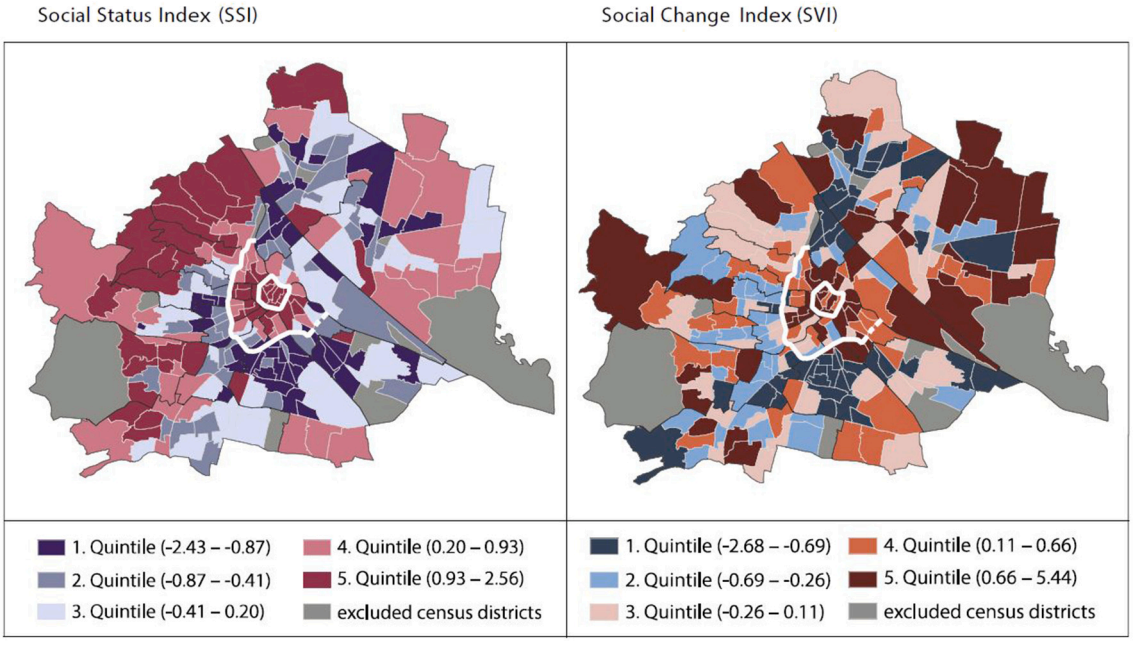

Fig. 3. Social status indicator and Social Change Index.
Source: own depiction.

although there is a clear gap in the pattern to the east of the inner city, with neighborhoods experiencing a status increase relative to the city-wide development.

When we compare the geography of the social status in 2011 and the changes between 2011 and 2016, we see several differences. In the west of the city, the 2011 status was particularly high, while the status change between 2011 and 2016 was not. A similar pattern is detectable in the southwest of the city, where the social status increase is more scattered. In terms of similarities, the geography of status change in Transdanubia fairly closely follows the structure of the 2011 status: higher-social

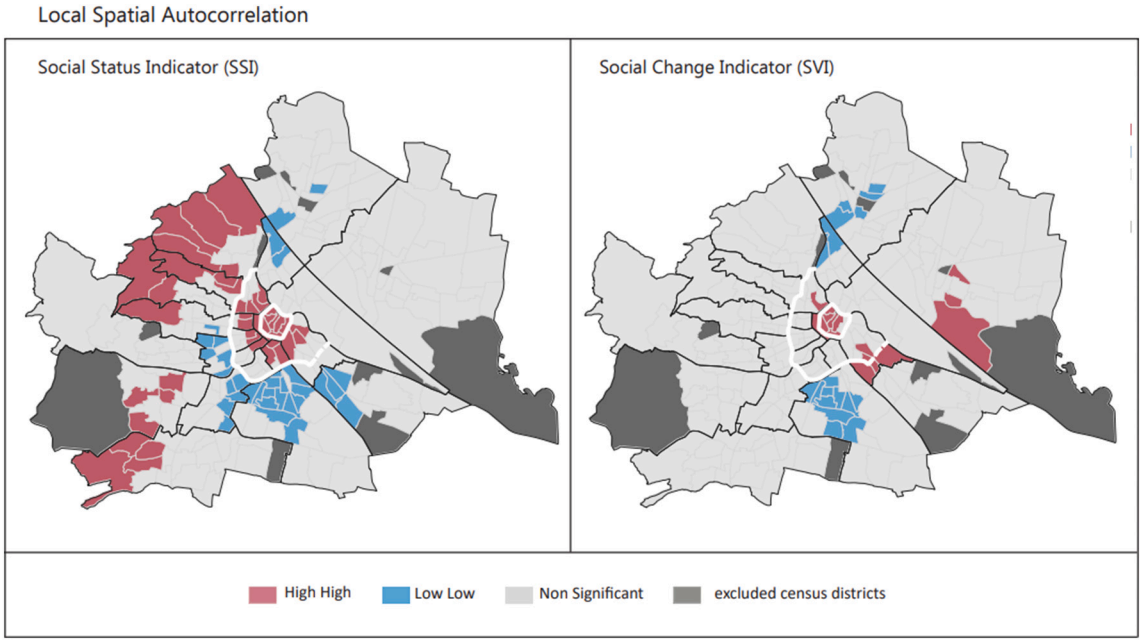

Fig. 4. Local spatial autocorrelation.
Source: own depiction.

status areas experienced the highest increase and vice versa. This is also observable in many Cisdanubia's census districts, for instance, those within the Gürtel were among the highest-status areas in 2011 and experienced the starkest status increase in the period until 2016. Meanwhile, the reverse is true for the neighborhoods around the Gürtel, particularly south of the inner city. Such a parallel between social status and change therein suggests growing socio-spatial inequality.

Cluster formations based on the Local I statistic are again shown on the right side of Fig. 4. It becomes apparent that significant cluster formation in status change is much less clear cut compared to initial social status. Nonetheless, High-High clustering can be confirmed within the city center as well as the aforementioned gap to the east of the Gürtel. Low-Low clustering can again be found south of the Gürtel as well as along those northern areas which were already identified as low-status clusters. Thus, clustering in in the initial low status resembles clustering in status downgrading. Interestingly, there is no analogous clear-cut relationship between high initial status clustering and further upgrading as the northwestern and southwestern high-status clusters do not show systematic upgrading. Still, the city center exhibits significant High-High clustering in both initial status and status change.

The changes between 2011 and 2016 did not lead to allover increased spatial clustering. The Moran's I statistic of the Social Status Index in 2016 with a value of $I = 0.55$ basically matches the value from 2011, thus indicating no relevant changes in the intensity of spatial clustering of low or rather high-status areas. This fits with our previous findings: as the status changes between 2011 and 2016 correspond to a considerable degree to the status level of 2011, with downgrading concentrated in lower-status areas and vice versa, the spatial location of high and low-status areas did not change significantly.

6.2. *Is there evidence of growing socio-spatial inequality?*

To determine whether we can observe increased socioeconomic inequality for the given time period, we need to link the initial status to status change. The scatter plot in Fig. 5 suggests a positive relation between starting position and relative status upgrading. We observe a clear tendency of initially below-average social status areas to also display relative status downgrading with approximately 78 % of observations with a negative SSI also having a negative SCI value. At the same time,

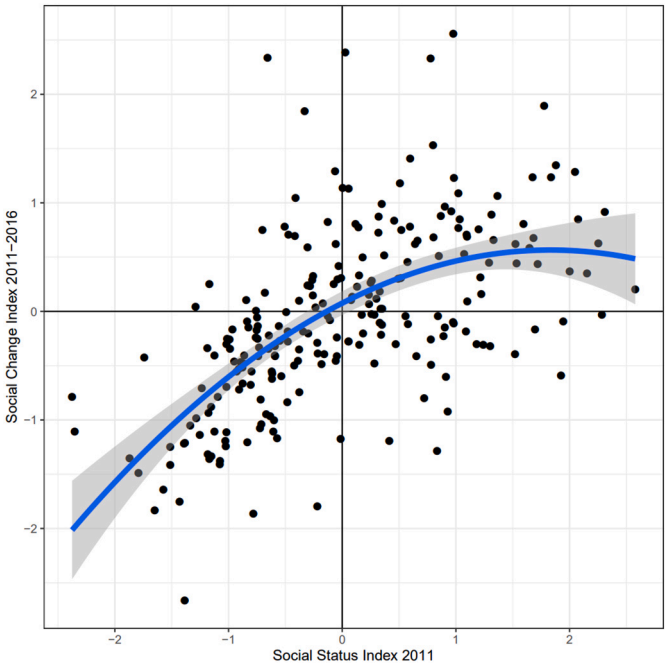

Fig. 5. Relationship between Social Status Index (SSI) and Social Change Index (SCI).
Source: own depiction.

around 68 % of observations with a positive SSI also show a positive SCI value.

However, the relationship does not appear to be linear over the whole domain but exhibits a flattening off toward higher-status values. This would suggest a divergent behavior both between high and low-status areas and within the group of low-status areas. For the latter this is driven by stronger relative downgrading of census districts at the bottom end of the distribution compared to those with only slightly negative SSI values, which on average exhibit only light relative downgrading.

We further test this relationship by running the set of regressions (see Table 1). As expected, the simple linear regression (OLS1) confirms a significant positive relationship between SCI and SSI, indicating ongoing polarization of social status between 2011 and 2016. However, also incorporating a quadratic term (OLS2), supports the notion of a nonlinear relationship. A significantly negative quadratic term shows that expected relative status increases decrease with higher initial status. For the very top end of the distribution, this even implies slight SCI decreases with further rising status values.[7] Due to the simple way we model nonlinearity and the low number of observations at the top end of the distribution, we might, however, be prone to overestimate the expected decrease in marginal SCI change.

Therefore, we do not want to overemphasize convergence in the spatial units with positive expected upgrading. We further detect three influential outliers in our data, which all exhibit well-above-average SCI values. While two are of low initial social status and have presumably profited immensely from the opening of Vienna's new main train station (referred to as Outlier 1 and 2 in Table 1), the third is located within the Ring and represents further status upgrading at the very top end of the distribution (Outlier 3 in Table 1). We exclude the influence of these outliers by introducing observation-specific dummy variables (OLS3).

We now test the residuals of our OLS models for spatial autocorrelation in order to detect potential non-randomness in our data stemming from their spatial nature. Although the Lagrange multiplier (LM) test for spatial autocorrelation of the OLS residuals (Anselin et al., 1996) remains inconclusive, the Moran's I statistic of the regression residuals indicates significantly positive spatial dependency. Thus, we further enlarge our model with a spatially lagged dependent variable (SAR). However, controlling for these spatial spillover effects does not substantially change the estimated effects, confirming our previous findings that the relationship between SSI and SCI indeed flattens off with rising SSI values. Although Table 1 shows that both the SSI and the quadratic term have a highly significant coefficient and are roughly of the same magnitude as before, we cannot continue with a simple ceteris paribus interpretation of the coefficients as in the OLS cases (LeSage & Pace, 2009). Instead, we report the direct effects of a hypothetical one-unit increase in initial status by area.[8] In this way, we are simultaneously considering the spillback effects stemming from the spatial dependency of the dependent variable and the quadratic nature of the fitted function. Fig. 6 shows the spatial pattern of the idiosyncratic direct effects. We can see that intervention in the aforementioned donut around the Gürtel, especially to the south, would render the highest expected returns in status upgrading of socioeconomically disadvantaged neighborhoods.

Table 1
Regression on SCI.

	OLS1	OLS2	OLS3	SAR
Constant	5.812e-17	0.05640	0.07970	0.086170
SSI	4.615e-01***	0.47883***	0.52626***	0.457361***
SSI^2		−0.05663	0.14942***	0.146883***
Outlier 1 (cen. distr. 9030111)			6.49138***	6.246903***
Outlier 2 (cen. distr. 9100101)			5.01952***	5.208211***
Outlier 3 (cen. distr. 9010103)			4.93200***	4.868419***
Rho				0.25216***

Note: *p < 0.1, **p < 0.05, ***p < 0.01.

We can thus summarize our interim results in the following way: marginal increases in initial status are associated with a high increase in the SCI level for low-status observations and a comparatively low increase for initially medium to high-status observations. On the one hand, this implies further expected divergence for units currently within the lower half of the status distribution if current developments continue. On the other, for those observations with an above-average status, the model implies slow convergence of absolute status. Expected upgrading starts from slightly below-average initial status areas onward up to the already highest-status areas. Conversely, the vast majority of below-average initial status units can expect further downgrading of their socioeconomic status relative to the citywide average.

Having assessed the general relationship between our status and change indicator across census districts, we further inspect the development of our partial indicators. This both serves as a robustness check that our SCI actually measures a multidimensional development and, at the same time, provides insights into the development of the respective partial indicators. Fig. 7 shows the distribution of the SCI, as well as partial change indicator values by SSI quintile.[9] If we look at the partial indicator development compared to the respective city average between 2011 and 2016 separately, their median development within the SSI quintile nearly always points in the same direction (with the one exception of university graduates in the second-lowest quintile, which is slightly positive). Hence, the relative index development within the SSI quintiles is indeed not driven by single indicators but based upon multidimensional developments. Interestingly the development of the share of university graduates roughly corresponds to the citywide trend for the second and third status quintile, while showing clearly above-average upgrading in the fourth and fifth quintile and a strong relative downgrading in the first quintile. The three other partial indicators exhibit markedly below-average developments in both the first and second quintile, while showing mostly strong above-average developments in the third to fifth quintiles, with the exception of income in the fourth quintile, where the median is only slightly above the city average. These findings suggest ongoing divergence is driven by developments in all considered dimensions and thus is indeed a multidimensional phenomenon. Also notable is that the middle of the status distribution apparently belongs to the thriving part of the city, even outperforming the fourth quintile in terms of income upgrading, when the median is considered.

We finalize the analysis by comparing the results to more traditional inequality metrics (Fig. 8). The first column lists the relative measures, the second the absolute measures, and the third the intermediate measures for each year between 2011 and 2016. We find stagnation to small decreases in relative inequality across all four partial indicators. On the other hand, the absolute measures of inequality paint a very different picture, with strong increases in concentration of the unemployed population, benefit recipients, and university graduates. Absolute income inequality also increases, especially between 2015 and 2016, but to a lesser degree than the other three variables. This is accompanied by clear increases in intermediate inequality with respect to the unemployed population, benefit recipients, and university graduates and stagnation regarding intermediate income inequality.

With both the absolute and intermediate metrics pointing to divergence, this confirms our findings, which also show absolute divergence. Slightly shrinking inequality in relative terms does not contradict our results, but most likely stems from relative partial indicator upgrading in the middle of the distribution, which we found to be similar if not higher than for the fourth quintile.

We can summarize our findings in six points: First, Vienna's social geography was fairly divided in 2011, with concentrations of high-status

[7] It is important to distinguish between the expected change in SCI referring to the slope of the regression line and the expected change in status, referring to whether the model predicts an SCI value above zero, which implies relative status upgrading.

[8] Idiosyncratic direct effects correspond to $\frac{\delta y_i}{\delta x_i}$.

[9] We use the share of non-benefit recipients and the share of the employed workforce instead of benefit recipients and unemployed share, so that all indicators have the same numerical direction.

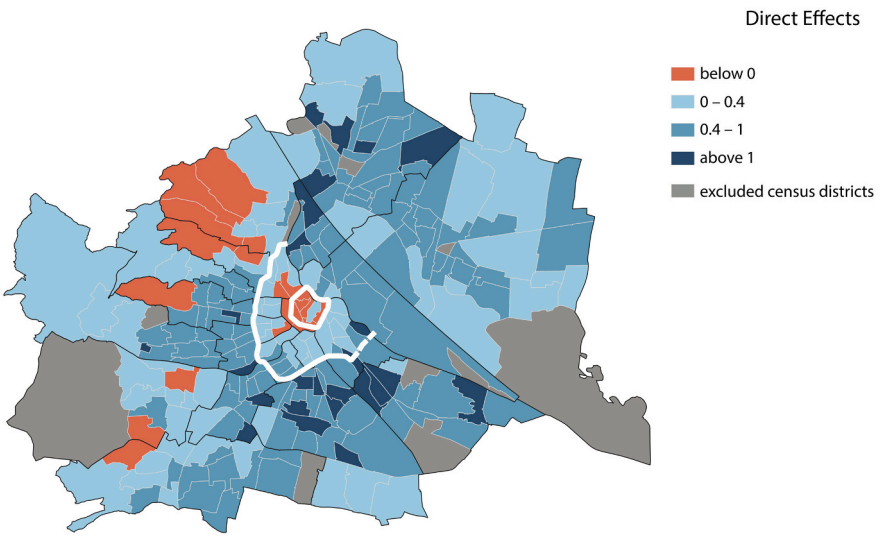

Fig. 6. Direct effects of Social Status Index (SSI) on Social Change Index (SCI).
Source: own depiction.

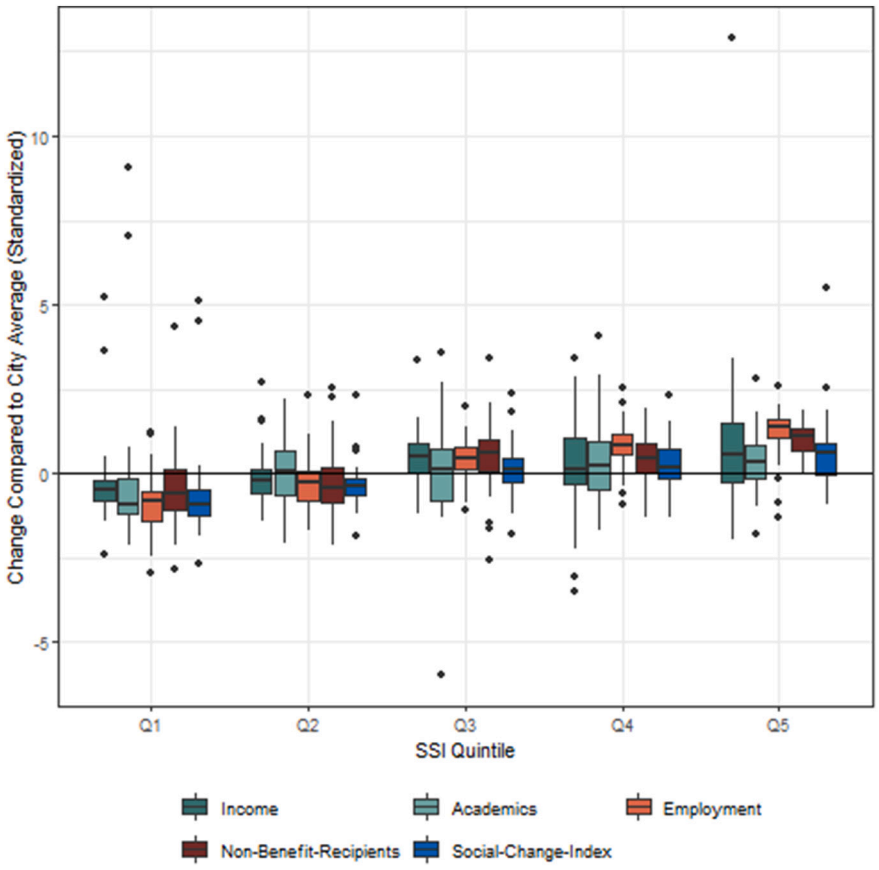

Fig. 7. Boxplots of SCI and partial indicator development by SSI quintile.
Source: own depiction.

areas in the center and the northwest of the city and low-status areas concentrated to the south of the Gürtel. Second, socioeconomic status upgrading was similarly concentrated in the city center, where the socioeconomic status was already high, while a lot of southern areas, with initially low-status values, faced further downgrading. Third, in line with these results, the analysis of spatial clustering shows that the observed changes in status up- or rather downgrading were not accompanied by changed spatial clustering, with the location of high and low-status areas remaining fairly stable overall. Fourth, after controlling for spatial dependence and nonlinearities, we still find a significant relationship between initial status and upgrading, with a flattening off toward the top end of the distribution. Thus, we conclude all-over divergence due to the expected relative decline in status for most of the below-average units and expected upgrading for all of the

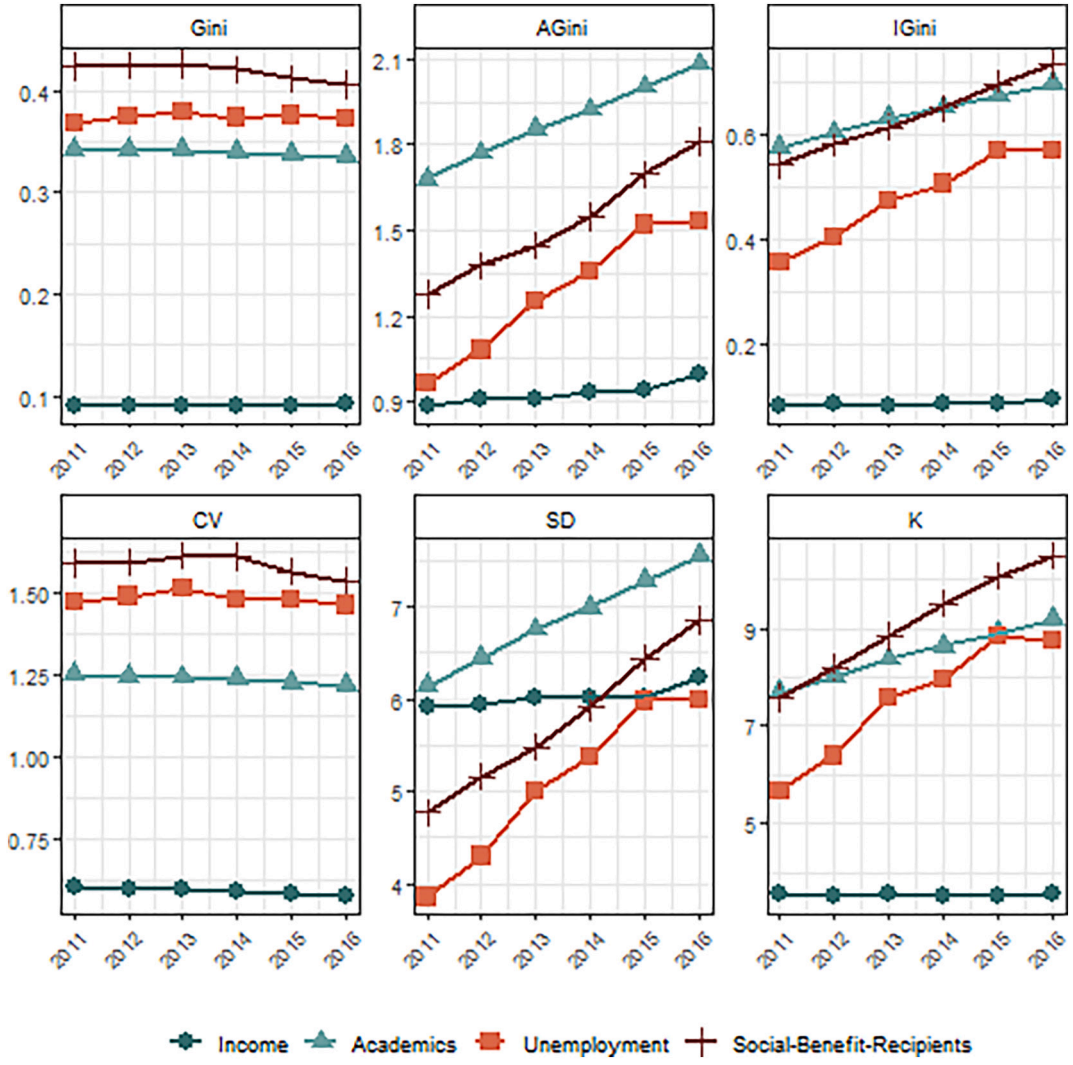

Fig. 8. Inequality measures of partial indicators 2011–2016.
Source: own depiction.

above-city-average units. Whether there is indeed convergence within the top half of the distribution, or whether this is just an artifact of the relatively simply modeled nonlinearity, remains to be seen. Fifth, the analysis of the distribution of the partial indicators shows that we do indeed observe a multidimensional development. Sixth, and finally, comparison of our results with several absolute and intermediate inequality measures confirms our notion of ongoing divergence, i.e., growing socio-spatial inequality, in absolute terms.

How to explain these growing, multi-dimensional status differences between spatial units amidst a fairly stable spatial clustering of low and high-status areas? The above-discussed, crisis-related shifts on the labor market and the housing market are revealing in this respect. On the labor market, aggregate unemployment levels have risen, but, as our analysis shows, in spatially highly uneven ways, affecting lower status areas in particular. This dynamic of low-status area downgrading was further promoted by income developments. The rise in income inequality in the post-crisis context in tandem with the spatial divisions in the city's social geography prior to the crisis meant that incomes decreased particularly in lower status areas. These developments were reinforced by the uneven development of the city's housing market since 2008. Higher rent increases in inner city areas in the existing housing stock and higher rents in new built developments made it more difficult for low-status households to reside in, or move to, higher status areas, promoting a more pronounced sorting of households following their socio-economic position in urban space. These structural shifts, then, are key variables to account for the growing socio-spatial inequalities.

7. Concluding remarks

Drawing on compound indices, GIS mapping, regression analyses and several inequality metrics as well as a small-scale level of analysis, this study demonstrates that in the “very” European city of Vienna, socio-spatial inequalities have been growing in the post-crisis context of rising inequality on the labor market and an uneven restructuring of the urban housing market. If previous research has found that prior to the crisis, Vienna's social geography had become more polarized (Hatz et al., 2016), we show that this trend has continued in the sense that the absolute inequality in socioeconomic status between spatial units in the city has increased. Importantly, the analysis reveals that this is not the outcome of a polarization across the entire distribution of spatial units, but especially results from low-status areas that cannot keep up with the pace of upgrading in the rest of the city. Moreover, increasing socio-spatial inequality, as we have shown, is not driven by a single indicator of socioeconomic status, but by a multidimensional development across different domains.

While our study focuses on the case of Vienna in particular, our findings have broader implications for the debate on socio-spatial inequalities in the European city. First, Vienna, as we have argued,

represents several characteristics of the European city model in a particularly pronounced form. Researching the developments of socio-spatial inequalities there, may thus serve as a kind of "stress test" for arguments about the European city more broadly. If, even here, we see rising socio-spatial inequalities, this supports recent arguments that the institutional arrangements of the European city are transforming in ways that such inequalities are on the rise (Tammaru et al., 2016) and runs counter to arguments that emphasize the continuity of such arrangements (cf. Le Galès, 2002). Second, it is relevant to note that the structural changes that have affected Vienna related to unemployment, rising income inequality, and an uneven housing market development since the financial crisis, have affected many other European cities too, although to different degrees (Giannakis & Bruggeman, 2017; Zwiers et al., 2016). Of course, these changes were mediated by a nationally and locally specific labor market, welfare and housing market policies and contexts and can thus be expected to differ in their impact across cities. Vienna is a case, however, where the existing institutional arrangements concerning the relatively protected labor market, limited size of the financial sector, and highly regulated housing market, have certainly dampened the crisis impacts more than in other cities. Therefore, cases with fewer institutional protections in place may have experienced even more drastic changes in the level of socio-spatial inequalities.

Our study also breaks new ground methodologically. While socio-spatial inequalities in urban studies are typically analyzed using segregation indices, our paper draws on the spatial unit approach more common in economic geography. Given the recent rise in socio-spatial inequalities in the context of a rapidly changing and crisis-driven economic and regulatory environment, we are convinced that such a move is necessary to widen the methodological toolkit available and thus gain new, and more nuanced insights beyond established disciplinary boundaries. We have, however, not only adopted an existing approach from a neighboring field, but also developed it further, taking inspiration from the wider inequality literature. This means, at the same time, that strictly comparable studies from other contexts are not yet available and should be conducted using the framework presented here. The relevance of our perspective is rendered particularly evident by a comparison of absolute and relative inequality measures, which shows that it is specifically the absolute inequality that has increased in Vienna, while relative inequality measures have remained fairly stable. Further, comparative research on other European cities would be highly desirable in this respect to test the generalizability of our findings in other cases and contexts.

Meanwhile, our study invites comparative analyses with cities beyond Europe. Recent research shows, for example, that in the United States, the financial crisis has triggered rising spatial divisions related to clustered foreclosure activities and house price developments (Shelton, 2018; Zwiers et al., 2016). Meanwhile, in the Canadian context, intensified gentrification of inner cities and a suburbanization of poverty, related to the operation of financialized housing investors is altering the regional social geography (August & Walks, 2018). While cross-continental comparisons of socio-spatial inequalities are still rare (see Shi & Dorling, 2020), analyses of this sort could yield relevant insights into the differing impact of the financial crisis in a more global context. The framework developed in this paper provides a potentially significant toolbox to enrich such comparisons.

CRediT authorship contribution statement

Justin Kadi: Conceptualization, Writing – original draft, Writing – review & editing, Funding acquisition. **Selim Banabak:** Formal analysis, Visualization, Conceptualization, Writing – original draft, Writing – review & editing. **Antonia Schneider:** Visualization, Formal analysis, Conceptualization, Writing – original draft.

Declaration of competing interest

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

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References

Aalbers, M. B., Hochstenbach, C., Bosma, J., & Fernandez, R. (2021). The death and life of private landlordism: How financialized homeownership gave birth to the buy-to-let market. *Housing, Theory and Society, 38*(5), 541–563.

Andersson, R., & Hedman, L. (2016). Economic decline and residential segregation: A swedish study with focus on Malmö. *Urban Geography, 37*(5), 748–768. https://doi.org/10.1080/02723638.2015.1133993

Anselin, L. (1995). Local indicators of spatial association—LISA. *Geographical Analysis, 27*(2), 93–115.

Anselin, L. (2013). *Spatial econometrics: Methods and models* (Vol. 4). Springer Science & Business Media.

Anselin, L., Bera, A. K., Florax, R., & Yoon, M. J. (1996). Simple diagnostic tests for spatial dependence. *Regional Science and Urban Economics, 26*(1), 77–104.

Atkinson, A. B., & Brandolini, A. (2010). On analyzing the world distribution of income. *The World Bank Economic Review, 24*(1), 1–37.

August, M., & Walks, A. (2018). Gentrification, suburban decline, and the financialization of multi-family rental housing: The case of Toronto. *Geoforum, 89*, 124–136.

Boserup, S. H., Kopczuk, W., & Kreiner, C. T. (2016). The role of bequests in shaping wealth inequality: Evidence from Danish wealth records. *American Economic Review, 106*(5), 656–661.

Bosmans, K., Decancq, K., & Decoster, A. (2014). The relativity of decreasing inequality between countries. *Economica, 81*(322), 276–292.

Boterman, W., Musterd, S., & Manting, D. (2020). Multiple dimensions of residential segregation: The case of the metropolitan area of Amsterdam. *Urban Geography*. https://doi.org/10.1080/02723638.2020.1724439

Cassiers, T., & Kesteloot, C. (2012). Socio-spatial inequalities and social cohesion in european cities. *Urban Studies, 49*(9), 1909–1924.

Crouch, C. (1999). *Social change in Western Europe*. Oxford: Oxford University Press.

Dijkstra, L., Garcilazo, E., & McCann, P. (2015). The effects of the global financial crisis on european regions and cities. *Journal of Economic Geography, 15*(5), 935–949. https://doi.org/10.1093/jeg/lbv032

Duncan, O., & Duncan, B. (1955). Residential distribution and occupational stratification. *American Journal of Sociology, 60*(5), 493–503.

Fainstein, S. (1999). Can we make the cities we want? In S. Body-Gendrot, & R. Beauregard (Eds.), *The urban moment* (pp. 249—272). Thousand Oaks: Sage.

Forrest, R., & Hirayama, Y. (2018). Late home ownership and social re-stratification. *Economy and Society, 47*(2), 257–279.

Giannakis, E., & Bruggeman, A. (2017). Determinants of regional resilience to economic crisis: A european perspective. *European Planning Studies, 25*(8), 1394–1415.

Harper, S., King, N. B., Meersman, S. C., Reichman, M. E., Breen, N., & Lynch, J. (2010). Implicit value judgments in the measurement of health inequalities. *The Milbank Quarterly, 88*(1), 4–29.

Harvey, D. (2019). Anti-capitalist chronicles: Rate and mass of growth [Podcast]. Retrieved from https://www.democracyatwork.info/acc_rate_mass_of_growth.

Hatz, G. (2009). Features and dynamics of socio-spatial differentiation in Vienna and the Vienna metropolitan region. *Tijdschrift voor economische en sociale geografie, 100*(4), 485–501. https://doi.org/10.1111/j.1467-9663.2009.00554.x

Hatz, G., Kohlbacher, J., & Reeger, U. (2016). Socio-economic segregation in Vienna: A social-oriented approach to urban planning and housing. In T. Tammaru, S. Marcińczak, M. van Ham, & S. Musterd (Eds.), *Socio-economic segregation in european capital cities: East meets west* (pp. 80–109). London/New York, NY: Routledge.

Hochstenbach, C., & Arundel, R. (2020). Spatial housing market polarisation: National and urban dynamics of diverging house values. *Transactions of the Institute of British Geographers, 45*, 464–482. https://doi.org/10.1111/tran.12346

Hochstenbach, C., & Musterd, S. (2018). Gentrification and the suburbanization of poverty: Changing urban geographies through boom and bust periods. *Urban Geography, 39*(1), 26–53. https://doi.org/10.1080/02723638.2016.1276718

Kadi, J. (2015). Recommodifying housing in formerly "Red" Vienna? *Housing, Theory and Society, 32*(3), 247–265. https://doi.org/10.1080/14036096.2015.1024885

Kadi, J., & Ronald, R. (2014). Market-based housing reforms and the 'right to the city': the variegated experiences of New York, Amsterdam and Tokyo. *International Journal of Housing Policy, 14*(3), 268–292. https://doi.org/10.1080/14616718.2014.928098

Kadi, J., Hochstenbach, C., & Lennartz, C. (2020). Multiple property ownership in times of late homeownership: A new conceptual vocabulary. *International Journal of Housing Policy, 20*(1), 6–24. https://doi.org/10.1080/19491247.2019.1697514

Kadi, J., Vollmer, L., & Stein, S. (2021). Post-neoliberal housing policy? Disentangling recent reforms in New York, Berlin and Vienna. *European Urban and Regional Studies, 28*(4), 353–374.

Kazepov, Y. (2005). Cities of Europe: Changing contexts, local arrangements, and the challenge to urban cohesion. In Y. Kazepov (Ed.), *Cities of Europe: Changing contexts, local arrangements, and the challenge to urban cohesion* (pp. 3–42). Malden, MA: Blackwell.

Knieling, J., & Othengrafen, F. (2016). *Cities in Crisis: Socio-spatial impacts of the economic crisis in Southern European cities*. London/New York: Routledge.

Le Galès, P. (2002). *European Cities: Social conflict and governance*. Oxford: Oxford University Press.

LeSage, J., & Pace, R. K. (2009). *Introduction to spatial econometrics*. Boca Raton, FL: CRC Press.

Marcuse, P. (2005). Enclaves yes, ghettos no. In *Desegregating the city: Ghettos, enclaves, and inequality* (pp. 15–30). David Varady: State University of New York Press.

Méndez, M. L., & Otero, G. (2018). Neighborhood conflicts, socio-spatial inequalities, and residential stigmatization in Santiago, Chile. *Cities, 74*, 75–82.

Méndez, M. L., Otero, G., Link, F., López Morales, E., & Gayo, M. (2021). Neighborhood cohesion as a form of privilege. *Urban Studies, 58*(8), 1691–1711.

Morril, R. K. (1991). On the measure of geographic segregation. *Geography Research Forum, 11*, 25–36.

Moser, M., & Schnetzer, M. (2017). The income–inequality nexus in a developed country: Small-scale regional evidence from Austria. *Regional Studies, 51*(3), 454–466.

Musterd, S., Hochstenbach, C., & Boterman, W. (2020). Ripples of structural economic transformation: The changing social geographies of dutch metropolitan regions. *Applied Geography, 116*, Article 102151. https://doi.org/10.1016/j.apgeog.2020.102151

Musterd, S. (2020). *Handbook of urban segregation*. Cheltenham: Edward Elgar.

Musterd, S., & Ostendorf, W. (1998). *Urban segregation and the welfare state*. London: Routledge. https://doi.org/10.4324/9780203448533

Niño-Zarazúa, M., Roope, L., & Tarp, F. (2017). Global inequality: Relatively lower, absolutely higher. *Review of Income and Wealth, 63*(4), 661–684.

Novy, A., Redak, V., Jager, J., & Hamedinger, A. (2001). The end of red Vienna: Recent ruptures and continuities in urban governance. *European Urban and Regional Studies, 8*, 131–144. https://doi.org/10.1177/096977640100800204

OECD. (2013). Crisis squeezes income and puts pressure on inequality and poverty. Retrieved from: http://www.oecd.org/els/soc/OECD2013-Inequality-and-Poverty-8p.pdf.

Oesterreichische Nationalbank. (2019). *Wohnimmobilienpreisdaten (2019Q1)*. Oesterreichische Nationalbank. https://www.oenb.at/Geldpolitik/schwerpunkt_immobilienmarktanalyse.html.

Park, R. E., Burgess, E. W., & McKenzie, R. (1925). *The city: Suggestions for investigation of human behavior in the urban environment*. Chicago, IL: University of Chicago Press.

Ranci, C., Brandsen, T., & Sabatinelli, S. (2014). *Social vulnerability in European Cities: The role of local welfare in times of crisis*. Basingstoke/New York, NY: Palgrave Macmillan.

Ravallion, M. (2003). The debate on globalization, poverty and inequality: Why measurement matters. *International Affairs, 79*(4), 739–753.

Ronald, R., & Kadi, J. (2018). The revival of private landlords in Britain's post-homeownership society. *New Political Economy, 23*(6), 786–803.

Sassen, S. (1991). *The global city*. New York, London, Tokyo. Princeton: Princeton University Press.

Shelton, T. (2018). Mapping dispossession: Eviction, foreclosure and the multiple geographies of housing instability in Lexington, Kentucky. *Geoforum, 97*, 281–291.

Shi, Q., & Dorling, D. (2020). Growing socio-spatial inequality in neo-liberal times? Comparing Beijing and London. *Applied Geography, 115*, 102–139.

Siebel, W. (2004). *Die europäische Stadt [The European City]*. Frankfurt: Suhrkamp.

Springler, E. (2019). Die Rückkehr der wohnungsfrage: Soziale bruchlinien in Österreich nach der krise [The return of the housing question: Social fault lines in Austria after the crisis]. *Kurswechsel*.

Statistics Austria. (2010). *Allgemeiner Einkommensbericht 2010. Statistischer Annex*. Statistics Austria.

Statistics Austria. (2011). Register-based census [data set]. Retrieved from: http://www.statistik.at/web_en/statistics/PeopleSociety/population/population_censuses_register_based_census_register_based_labour_market_statistics/index.html.

Statistics Austria. (2012). *Allgemeiner Einkommensbericht 2012. Statistischer Annex*. Statistics Austria.

Statistics Austria. (2014). *Allgemeiner Einkommensbericht 2014. Statistischer Annex*. Statistics Austria.

Statistics Austria. (2016). *Allgemeiner Einkommensbericht 2016. Statistischer Annex*. Statistics Austria.

Statistics Austria. (2018). *Allgemeiner Einkommensbericht 2018. Statistischer Annex*. Statistics Austria.

Statistics Austria. (2019). *Microcensus, yearly average*. Statistics Austria.

Subramanian, S., & Jayaraj, D. (2013). The evolution of consumption and wealth inequality in India: A quantitative assessment. *Journal of Globalization and Development, 4*(2), 253–281.

Marcińczak, S., Musterd, S., van Ham, M., & Tammaru, T. (2016). Inequality and rising levels of socio-economic segregation: Lessons from a pan-European comparative study. In T. Tammaru, S. Marcińczak, M. van Ham, & S. Musterd (Eds.), *Socio-economic segregation in European Capital Cities: East meets West* (pp. 358–383). London/New York, NY: Routledge.

Tammaru, T., Marcinczak, S., Aunap, R., van Ham, M., & Janssen, H. (2020). Relationship between income inequality and residential segregation of socioeconomic groups. *Regional Studies, 54*(4), 450–461. https://doi.org/10.1080/00343404.2018.1540035

Tammaru, T., van Ham, M., Marcińczak, S., & Musterd, S. (2016). *Socio-economic segregation in European capital cities: East Meets West*. Retrieved from: London/New York, NY: Routledge https://www.taylorfrancis.com/books/e/9781315758879.

Tockner, L. (2017). Mieten in Wien und Österreich 2008 bis 2016 [Rents in Vienna and Austria, 2008–2016]. Arbeiterkammer Wien [Chamber of Labor, Vienna]. Retrieved from https://www.arbeiterkammer.at/infopool/wien/Mieten_in_Oesterreich_und_Wien_2008_bis_2016.pdf.

van Gent, W., Das, M., & Musterd, S. (2019). Sociocultural, economic and ethnic homogeneity in residential mobility and spatial sorting among couples. *Environment and Planning A: Economy and Space, 51*(4), 891–912.

van Gent, W., & Hochstenbach, C. (2020). The neo-liberal politics and socio-spatial implications of dutch post-crisis social housing policies. *International Journal of Housing Policy, 20*(1), 156–172.

van Kempen, R., & Murie, A. (2009). The new Divided City: Changing patterns in european cities. *Tijdschrift voor economische en sociale geografie, 100*(4), 377–398. https://doi.org/10.1111/j.1467-9663.2009.00548.x

White, M. J. (1983). The measurement of spatial segregation. *American Journal of Sociology, 88*(5), 1008–1018.

Stadt Wien. (2020a). Bevölkerungsstand – Statistiken [population statistics). Retrieved from: https://www.wien.gv.at/statistik/bevoelkerung/bevoelkerungsstand/.

Stadt Wien. (2020b). Arbeitslosenquoten in Wien nach nationaler und internationaler Definition seit 2000 [Unemployment rates in Vienna since 2000 according to national and international definitions. Data set]. Retrieved from: https://www.wien.gv.at/statistik/arbeitsmarkt/tabellen/arbeitslosenquoten-zr.html.

Yao, J., Wong, D. W. S., Bailey, N., & Minton, J. (2019). Spatial segregation measures: A methodological review. *Tijdschrift voor economische en sociale geografie, 110*(3), 235–250. https://doi.org/10.1111/tesg.12305

Zwiers, M., Bolt, G., van Ham, M., & van Kempen, R. (2016). The global financial crisis and neighborhood decline. *Urban Geography, 37*(5), 664–684. https://doi.org/10.1080/02723638.2015.1101251

Zwiers, M., Kleinhans, R., & van Ham, M. (2015). Divided cities: Increasing socio-spatial polarization within large cities in the Netherlands (IZA Discussion Paper No. 8882). Retrieved from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2575062.