Urban Planning (ISSN: 2183–7635)
2022, Volume 7, Issue 3, Pages 15–34
https://doi.org/10.17645/up.v7i3.5306

Article

Working From Home and Covid-19: Where Could Residents Move to?

Johannes Moser *, Fabian Wenner, and Alain Thierstein

Chair of Urban Development, Technical University of Munich, Germany

* Corresponding author (johannes.moser@tum.de)

Submitted: 25 January 2022 | Accepted: 5 April 2022 | Published: 29 July 2022

Abstract
As a protective measure during the Covid-19 pandemic, in Spring 2020, a high number of employees began relocating their workplace to their homes, many for the first time. Recent surveys suggest that the share of those working from home (WFH) will remain higher than before the pandemic in the long term too—with correspondingly fewer commuting journeys. Workplaces are still often concentrated in inner cities, into which workers commute from more outlying areas. However, classical geographical economic theory suggests that a reduced need for commuting might lead to a reorientation of residential preferences amongst employees towards even fewer urban areas, as households trade off the disamenity of commuting against lower housing costs and more living space. This article investigates how such consequences could unfold in space. The Munich Metropolitan Region is characterised by a high share of knowledge-based jobs suitable for WFH and thus serves as our case study. We collect data at the municipality level for relevant aspects of residential location choices and develop an index for the potential of additional residential demand through increased WFH for each municipality in the Munich Metropolitan Region. Crucially, a municipality's potential depends on the number of commuting days per week. Keeping the weekly commuting time budget constant, an increase in WFH, or a reduction in commuting days allows a longer commuting time per trip. We visualise our results and sensitivities with maps. We observe a gradual yet discontinuous decay of potentials from the region's core to the fringes with an increase in WFH days.

Keywords
commuting; Covid-19; regional development; working from home

Issue
This article is part of the issue "The Resilient Metropolis: Planning in an Era of Decentralization" edited by Thomas J. Vicino (Northeastern University).

1. Introduction

In most European cities, suburbanisation has been the norm over the last century because of improved transportation technologies and their broader spread among higher shares of the population (Teaford, 2011). However, most workers commuted to their workplace daily and were therefore forced to reside within a reasonable spatial distance from it. The rigidity of this spatial relationship may be in the process of disintegration with the advent of the phenomenon of working from home (WFH).

WFH is not new and was already an occasional practice more than 20 years ago (Felstead & Jewson, 1999), particularly in knowledge-intensive sectors of the economy, whose tasks often only require a computer with Internet access and a small and exceptional number of "digital nomads" who enjoy full flexibility in terms of their work location. However, it was only the significant external shock of SARS-CoV-2 (Covid-19) and the resultant global pandemic that put WFH on the agenda on a large scale. Government measures to enforce physical distancing as a precaution against Covid-19 in many countries made WFH mandatory for those jobs that could be performed outside of the office, thus making WFH for many the temporary norm. Scholars discussed the evidence of increased WFH from the start of the pandemic in both the US (Brynjolfsson et al., 2020) and in

Germany (Möhring et al., 2021). This challenge often forced employers to implement the required technological infrastructure and new flexible work arrangements. There are already strong signs that a higher share of WFH will become more firmly established in the future (Barrero et al., 2021). Because of the decreased importance of the physical proximity to places of work, individuals have increased freedom of choice as regards their place of residence. At the same time, an outright abandonment of the classical office is in most cases unlikely, even in the long term, particularly since innovation processes in firms continue to require initial and temporal physical proximity. Rather, such proximity must be seen as complementary to outward connectivity. Furthermore, the density of physical interaction is not only crucial for creative processes in firms but is a constituent of the appeal of cities in general (Weinig & Thierstein, 2021). Batty (2020), Glaeser (2022), and Keil (2020) discuss potential scenarios of post-Covid-19 urban structures. Numerous studies have analysed WFH in a spatial context: Cho et al. (2021) look at Covid-19-induced impacts on employment across metropolitan status and size, De Fraja et al. (2021) examine consequences of WFH on local labour markets in the UK, Davis et al. (2021) estimate the elasticity of substitution between WFH and in the office, and Ramani and Bloom (2021) find an increased demand for lower density neighbourhoods away from central business districts (CBDs) in the US and label this the "donut effect." In a similar vein, Rosenthal et al. (2021) observe a decreased commercial rent gradient associated with employment density, while Althoff et al. (2021) discuss the shifting spatial impacts of urban interdependencies between business service and local, non-tradable service workers. Nevertheless, residential decisions may be subject to altered spatial determinants. This article seeks to shed light on relevant determinants and provides a case study for the Munich Metropolitan Region (MMR). Since no statistical data on sustainable, long-term, post-Covid migration is available at the time of writing, we fall back on models of economic geography to project possible outcomes. Examining the literature, we proceed to estimate which municipalities in the MMR may harbour the potential for additional residential demand. This article is structured as follows: Section 2 delves into the literature for a theoretical background and Section 3 introduces the case study region MMR. In Section 4, we explain our approach and the data, while Section 5 discusses the results and, in Section 6, we verify the robustness of our results. Section 7 compares the WFH index results with short-term evidence on housing price data and, in Section 8, we look at the planning implications before reaching our conclusions in Section 9.

2. Theoretical Background

WFH had not been a widespread practice before the outbreak of the Covid-19 pandemic, even though it had already been technically feasible for quite some time. For example, around 56% of jobs in Germany were suitable for WFH before Covid-19, according to Alipour et al. (2020). Employers were often reluctant to embrace WFH due to its assumed disadvantages as regards the speed and quality of processes, innovative productivity, and the foundation of trust among the workforce, not forgetting the danger of shirking and prohibitively high costs of providing the technical infrastructure, such as hardware and software, for workers at home (Boland et al., 2020). On the other hand, there is considerable potential for cost-cutting since office rents and commuting costs can be reduced, as Haag (2020) discusses in the case of New York City. The situation for employees is more ambivalent, as Lord (2020) describes, because some prefer to separate home and work physically and are keen to meet colleagues in person, while others value saving the time and costs incurred by commuting and are therefore attracted to WFH (see Barrero et al., 2021; Shearmur et al., 2021).

WFH does not affect all areas equally and has been unevenly distributed among industries and spatially across regions (Bartik et al., 2020; Bick et al., 2020; Dingel & Neiman, 2020; Mongey & Weinberg, 2020; Reuschke & Felstead, 2020). The IT, finance, insurance, business services, entertainment, and education sectors in particular display an affinity to WFH. Highly qualified, above-average earners are thus disproportionately likely to make use of WFH (Schröder et al., 2020).

Over the course of the pandemic, with lockdowns and quarantine measures, firms and employees alike were by necessity forced to experiment with WFH. While some firms have already announced far-reaching plans for a continuation of WFH, even in a post-Covid scenario, some large high-tech companies such as Google are planning to implement "hybrid" workplace strategies that continue to require employees to live within commuting distance to the office in the future, as they deem a certain share of in-office collaboration necessary for successful team projects (Elias, 2020). For Germany, a recent study found that 35% of all employees are likely to engage in WFH either fully or partially after the Covid-19 pandemic, 17 percentage points more than before it (Berg, 2020). Surveys generally find that employees that are highly satisfied with WFH mention the positive effect of reduced stress from less daily commuting (Spellerberg et al., 2021). Consequently, it can be argued that a permanently higher share of WFH will be quite likely in the future (e.g., Rappaport, 2021), even though a certain degree of in-office presence will still be required. On average, it seems likely that many employees will spend two or three days per week WFH. Even though this shifting paradigm of work-life culture may not significantly alter the global dominance of metropolitan areas on a "macrogeographic" level, it nonetheless has spatial "microgeographic" consequences, as, for example, Florida et al. (2021) argue. First and foremost, there will be fewer commuter flows, especially to areas with high

concentrations of offices. Secondly, and the real focus of our study, are individuals' residential choices dependent upon the possibility of WFH. For further theoretical background on WFH and its relation to housing, see Stanton and Tiwari (2021).

In this study, we assume that: (a) Individuals prefer to have more space at home than less, also in order to be able to create a separate room for WFH; (b) individuals have only limited pecuniary resources and are attracted to areas with lower housing costs; (c) individuals (still) value reasonable accessibility to jobs, and will not become entirely "footloose," as they will still be required to spend part of the working week physically in the office; and (d) they value the existence and quality of certain local cultural, natural, and service amenities. Curfews and restrictions on the movement radius during the Covid-19 pandemic have further bolstered the latter through increased attention to the quality of dwellings and neighbourhoods (Weinig & Thierstein, 2021). As a result, households who shift to more WFH can lower their commuting costs and may move to potentially less expensive municipalities to have more space at home. In spatial terms, these relationships can be approximated using the monocentric urban model by Alonso (1964), Mills (1967), and Muth (1969) in the case of the MMR. Fewer weekly commuter trips translate into a lower disamenity of the distance to the urban centre, i.e., lower monetary and non-monetary transport costs. As a result, the land demand curve, the land price gradient, and ultimately the density gradient within the region become flatter and the functional (commuter) city-region expands, assuming a stable population and employment within the region. However, the selection process of a residential location is more complex than the model suggests, depending on further variables and demand patterns that differ by household groups (Thierstein et al., 2016), which must be considered when identifying areas with potential for added residential demand. For example, broadband Internet access gains in importance as physical meetings are replaced by video conferences with high data volumes.

3. Background on the Munich Metropolitan Region

The MMR is a functionally defined region in the southeast of Germany, characterised by relatively homogeneous internal commuter relationships, a commonly used infrastructure (e.g., hub airport MUC) and loosely woven governance by a registered association, with no formal administrative structures. The region is economically vibrant and shaped by industries that employ many highly qualified knowledge workers in WFH-suited industries (Alipour et al., 2020, 2021). Following the common description also employed by Thierstein et al. (2016), the MMR consists of 748 municipalities that are very different as regards various features such as housing prices, access to public transport and highways, or endowment with cultural and natural amenities as well as services. According to Kinigadner et al. (2016), average daily one-way commuting times in the MMR are around 50 minutes for tenants, while homeowners commute on average 67 minutes.

Figure 1, adapted from Thierstein et al. (2016), shows how the MMR is structured from a spatio-functional point of view. Morphologically, the region is rather monocentric. The City of Munich at the region's core is the main dominant centre of employment and therefore the most important destination for in-commuters. Augsburg, Ingolstadt, Landshut, and Rosenheim are the main regional sub-centres. The region's high labour demand and ambient living conditions continue to attract new residents to the region, who face an already strained supply of housing, resulting in the highest housing price level in Germany and one of the highest in Europe. For a case study, therefore, it serves well to investigate which municipalities within a metropolitan region may benefit or lose out from a shift to more WFH.

4. Methodology and Data

It is still unclear (a) what shares of the workforce will engage in WFH in the medium and long term and (b) how many days a week this share of workers will commute to offices. For this study, our informed guess is that an average worker will commute to work 2.5 days per week, which appears to be a reasonable solution that reflects the average between the extreme solutions of "no WFH at all" and "only WFH," as well as the manifold expressed opinions of "2–3 days" (Barrero et al., 2021). We are interested in the spatial dimension of these behavioural shifts, which is why we create a "WFH index" to assess which regions could be exposed as places of high potential for additional demand for housing. We construct a novel data set at the municipality level in the MMR. The components of the data set, including their weights in the WFH index, are described in Table 1. All of the variables are normalised via division by the maximum observation.

The WFH index is constructed by summing up the components' values multiplied by the respective weights. Housing costs are subtracted to penalise high values. Bearing in mind that individual residential preferences are heterogeneous and idiosyncratic (Hoshino, 2011), the weighting of the components is oriented on a large-scale inhabitant survey in the region (Thierstein et al., 2016).

The main identifying component is "accessibility," which records a change from a pre-Covid-19 to a post-Covid-19 pandemic state for both public and individual means of transport. Since this is the underlying key assumption of the study, we choose it to occupy one half of the WFH index with 25% each for the partially computed changes in accessibilities of public and individual means of transport. Housing costs play a substantial part in choosing the residential location for most individuals. The relationship between housing costs and

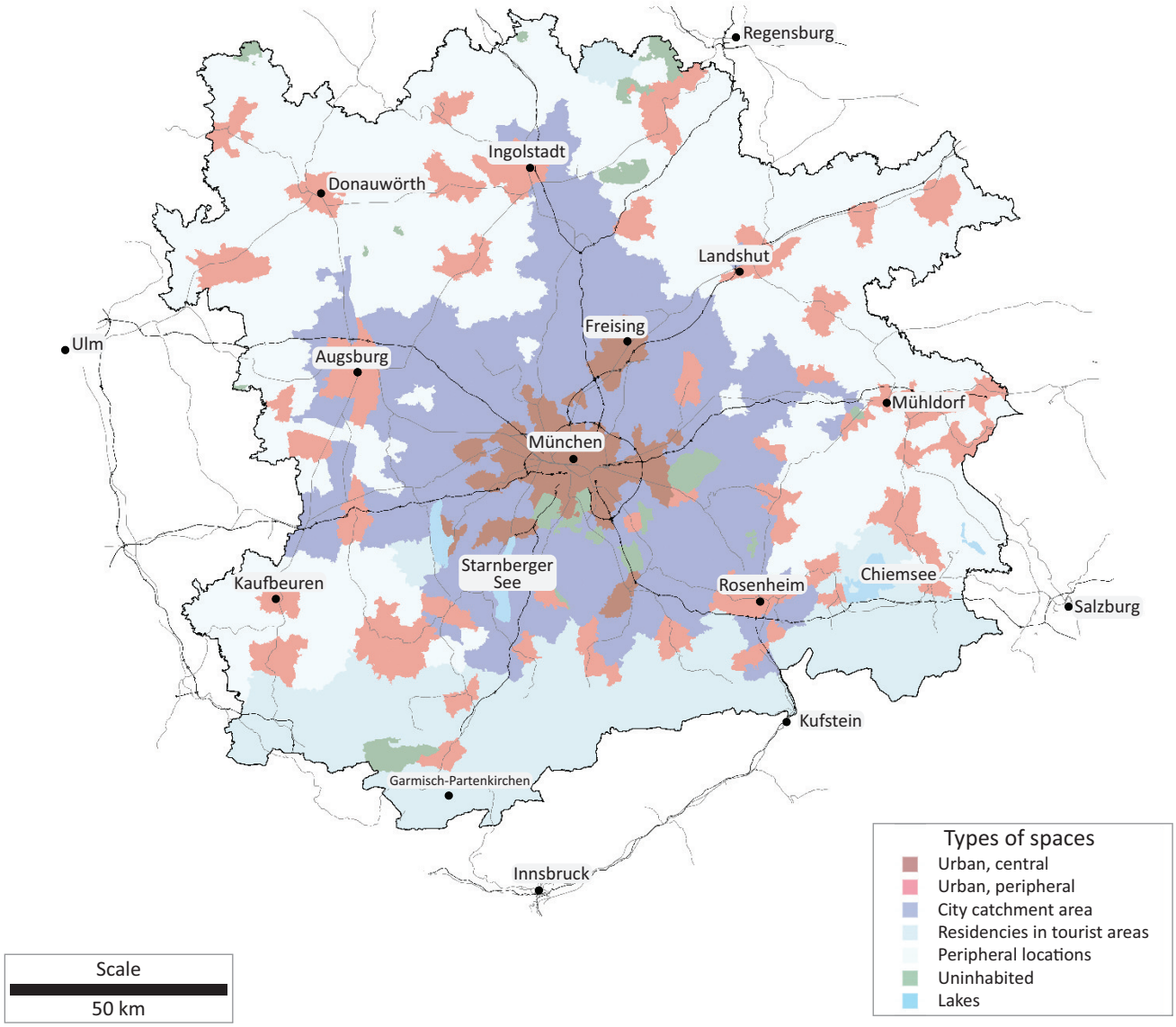

Figure 1. Types of spaces in the MMR. Source: Authors' work based on Thierstein et al. (2016).

income, however, varies depending on the income distribution: Lower-income groups spend more of their incomes on housing than top earners and this difference has increased over recent decades (in 2013, the lowest quintile spent 39% and the top quintile only 14% of their income on housing, while for the median income-earner this ratio is roughly 20% according to Dustmann et al. [2018]). As explained in Section 2, the average WFH worker tends to belong to higher earning groups. It was also assumed that WFH workers need on average more space at home to better be able to work, which leads to a trade-off between more accessible, smaller homes and larger but less accessible homes. Ultimately, this could lead to an equilibrium for a WFH worker with steady housing costs, whereby more square meters are available at home at a lower price. One cannot translate the ratio of housing costs over income directly into a weight in the WFH index, but we believe 20% to be an accurate configuration with 10% each for renting and buying. Broadband access and its speed play a crucial role for a WFH employee since frequent file-sharing and videoconferences as standard WFH activities require a high broadband capacity. If other members of the household also use the broadband connection at the same time, this becomes even more relevant. In rural areas in Germany, one cannot currently be sure of the existence of a high-speed broadband connection (Gürtzgen et al., 2021). As stated above, we assume 15% to be an appropriate choice, except for municipalities that fail to reach the minimum threshold of a broadband coverage of at least 90% of their households with at least 50 MBit/s. The remaining 15% of the WFH index are divided up among "soft" factors in the municipalities, by which we try to cover lifestyle aspects. By "amenities,'' we mean the existence of a historic core, hospitals, schools, and gastronomy and entertainment

Table 1. Description of WFH index.

Indicator		Operationalisation	Source	Weight
Housing costs	Public transport	Difference in gravity accessibility of jobs between 2.5 and five days of commuting per week	Jobs: Bundesagentur für Arbeit (2020); Statistik Austria (2021) Traffic: Deutsche Bahn (2021); OpenStreetMap Foundation (2021)	25%
	Individual transport			25%
Accessibility	Real-estate prices	Average prices per m² and municipality over 2018–2020 enter the index negatively valued	Boelmann and Schaffner (2021)	10%
	Rental prices			10%
Internet		Percentage of the covered area of municipality with access to broadband Internet of at least 50 Mbit/s; zero if less than 90%	atene KOM (2021)	15%
Public services, cultural facilities, and locational quality		Number of hospitals, secondary schools, museums, gastronomy businesses, and arts and entertainment firms per capita Existence of a historic urban core and share of vacation homes (as a proxy for locational appeal)	Agency for Digitisation, High-Speed Internet and Surveying (2016); Orbis (2021); Statistische Ämter des Bundes und der Länder (2020)	10%
Demography		Share of 18 to 29-year-old people	Statistische Ämter des Bundes und der Länder (2022)	2.5%
Local grocery stores		Existence of at least one grocery store	Discounto (2021)	2.5%

facilities in the municipality as "nice-to-have" features with 5%. "Vacation homes" with a weight of 5% function as a proxy for "natural beauty": Places where people spend their vacations tend to be located in landscapes that encourage sports activities such as hiking and skiing in the mountains or (sun-)bathing at the seaside or lakes (Kolko, 2012). Next, in line with Prenzel (2021), we argue that a high share of young(er) people in a region serves as a proxy for its appeal. However, we do not want to exaggerate the importance of this, thus attributing "young adults" a weight of 2.5%. Finally, a municipality that has one or more grocery stores potentially facilitates car-independent grocery shopping and thereby increases a family's flexibility, which increases the location's appeal. Kim et al. (2005) show that higher travel costs to a supermarket (among other factors) increase the willingness to move to a new residence. We therefore assign "groceries" a weight of 2.5%. Accessibility in municipality i is computed as follows:

$$A_i = \sum_j \frac{W_j}{e^{\beta d_{i,j}}},$$

where W_j is the number of jobs in municipality j, $d_{i,j}$ the travel time distance between i and j, and β a measure of the decay of distance. The difference between accessibility with five days commuting ($\beta = 0.035$) and accessibility with 2.5 days commuting ($\beta = 0.01725$) then enters the WFH index. The distance decay was calibrated using current commuting patterns of the MMR and is in line with previous literature (e.g., Ahlmeyer & Wittowsky, 2018). We assume stability of the total amount of time an individual is willing to commute per week in both pre- and post-Covid-19 periods. Hence, the parameters translate into a 50% reduction of the likelihood of commuting from every 20 minutes before the pandemic, to every 40 minutes after the pandemic. The accessibility values were calculated including a buffer zone of 40 km around the MMR to avoid a fringe bias.

Heterogeneous lifestyle preferences are likely to influence residential and mobility choices. Studies that try to simulate aggregate outcomes through the interplay of the sum of individual micro-decisions reflecting empirical or estimated distributions of socioeconomic variables (such as lifestyle preferences) could employ agent-based modelling techniques.

4.1. Correlations Between Indicators

To get a feel for the data in the WFH index, consider the heat map of correlations between several related variables in the MMR in Figure 2. The correlation coefficients range from −0.393 ("share vacation homes" and "Δ individual accessibility") to 0.996 ("number of residents" and "number of jobs"). The majority of the variables are weakly positively correlated. Both public and individual initial accessibilities are accessibilities with five days of commuting per week.

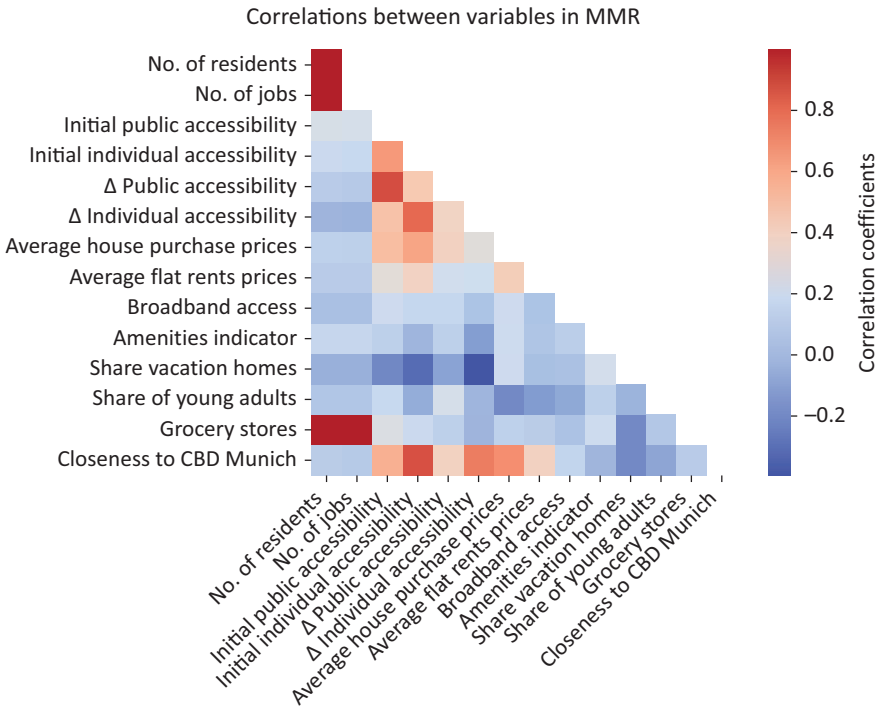

Figure 2. Correlation heat map between sub-indicators related to the WFH index. Note: Low correlation values are red and high correlation values are purple.

The changes in both accessibilities stem from the change from 5 to 2.5 days of commuting per week. Closeness to the CBD Munich is the inverse distance from a municipality's centroid to Munich CBD as the crow flies in km. A high correlation between initial individual accessibility and closeness to CBD Munich thus means that municipalities geographically proximate to Munich (low closeness values) are endowed with high individual accessibility values when their residents commute daily to their jobs. The low correlation between the share of holiday homes and accessibilities as well as the share of young adults show that holiday homes do indeed seem to be located on the periphery and deemed as unattractive for young adults.

5. Results

In this section, we start by discussing a map with the results of the WFH index. Subsequently, we put the results in perspective by presenting the correlation between the WFH index and its indicators.

5.1. The WFH Index Map

Figure 3 presents the MMR, with the City of Munich at its topographic centre, surrounded by the cities of Ulm and Regensburg in Germany and Salzburg, Kufstein, and Innsbruck in Austria. The green-coloured areas show municipalities in the MMR that display potential for additional demand for residential space induced by a general shift to more WFH. Municipalities with potential for additional residential demand are labelled as "high" for the 10th decile, "medium" for the ninth decile, and "low" for the eighth decile of the index respectively. Other municipalities show no added potential through WFH. We exclude any micro-spatial optimisation of residential choices within the City of Munich itself.

The largest concentration of added potential lies in the neighbouring municipalities to the northwest of the City of Munich. A corridor-like concentration begins in Dachau and stretches along the course of the highway and main railway line up to Ingolstadt. These areas are shaped by especially high accessibility values with the cities of Munich, Augsburg, and Ingolstadt close by, relatively low housing prices, and good broadband Internet availability due to the settlement of many high-tech firms. Another large concentration of potential can be found in and around Augsburg, the MMR's second-biggest city, which offers a less expensive city experience with advanced broadband capacities, while the City of Munich is still accessible within less than an hour. The southern part of the MMR in general does not seem to hold comparable potential. This outcome is partly due to the fact that real estate prices are exceptionally high. The southwest, around Kaufbeuren, offers lower residential costs but is quite rural with both low accessibility levels and a lower density of local supplies. However, the discontinuous corridor band from Munich's southeast to the Austrian border is an exception, which is also expressed in higher shares of holiday homes. Despite higher housing costs than in the southwest, this corridor benefits strongly from higher accessibility and amenities. To the east of Munich, a vast area encircling Mühldorf presents barely any potential, mainly due to

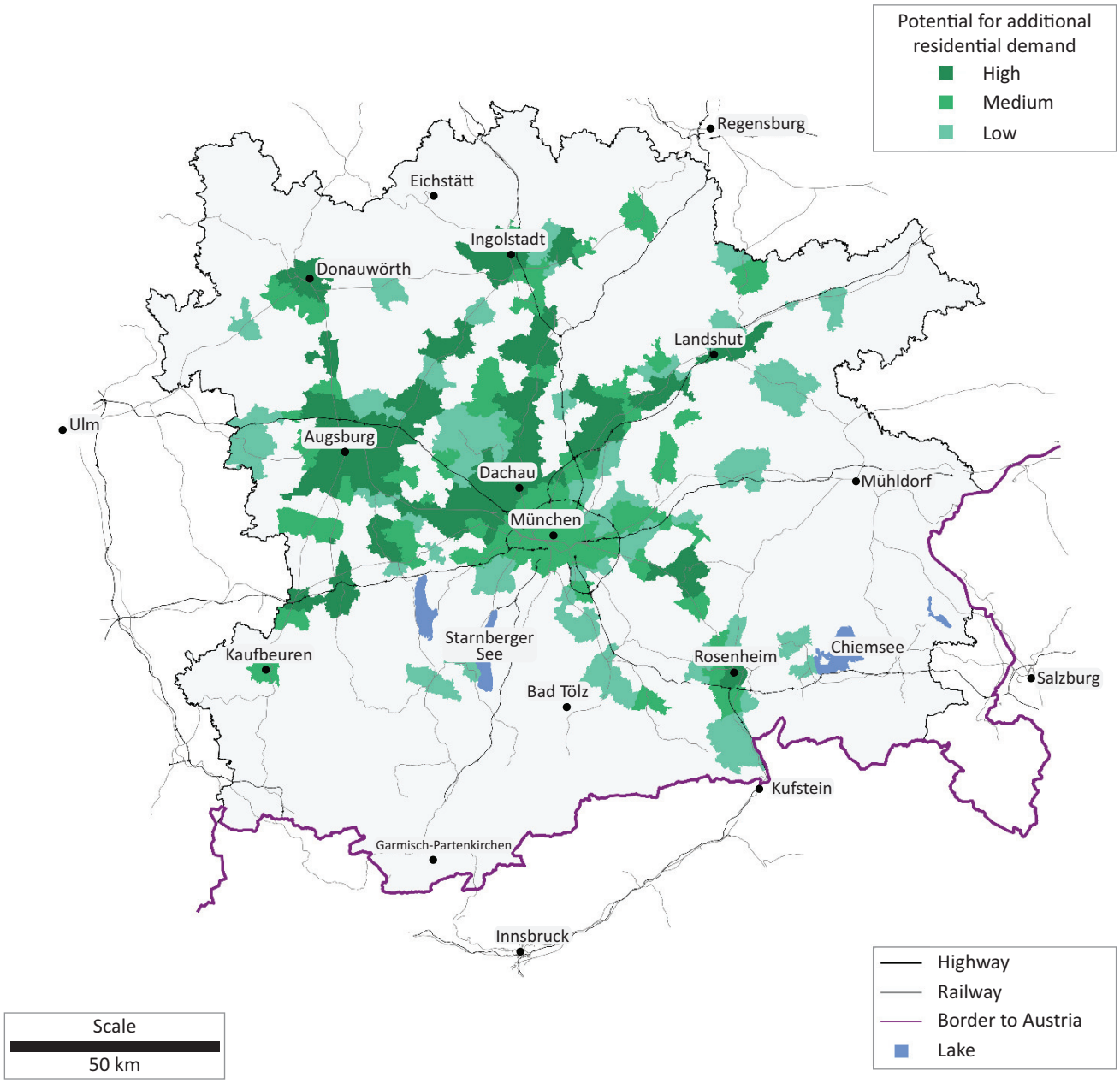

Figure 3. Municipalities with potential additional demand for residential space in the MMR.

limited accessibility, because housing prices are comparably moderate there. The overall pattern is quite heterogeneous, with municipalities that exhibit high added potentials often lying next door to those without, due to the highly differentiated distribution of certain decisive parameters of the WFH index used, such as the availability of broadband Internet and basic local facilities (e.g., shops). There is also a clear gradual reduction of potential towards the fringes of the MMR, resulting from the indices of accessibility change used. The City of Munich itself, despite remaining the most accessible municipality with the highest level of amenities in absolute terms, gains less in appeal as a residential location than the neighbouring municipalities in the north due to the high costs of housing. However, it is hard for smaller municipalities to overcome the appeal of an economically vibrant metropolis with many entertainment facilities amongst people with certain lifestyles. The City of Munich will only lose its potential according to the WFH index if the number of days spent commuting is reduced even further.

In summary, the following four observations can be made:

1. Physical proximity to large urban areas and jobs remains attractive when weekly regular commuting persists.
2. The more densely populated areas and more accessible northwest of the MMR exhibit more potential than the southeast.

3. The "secondary cities" close to a region's largest agglomeration show particularly high potential for an influx of residents. They could act as a substitute for the City of Munich as they display urban qualities while being more affordable than Munich itself.
4. Locations that are accessible by public transport are especially attractive because accessibility by car has less regional variation. The corridors along rail infrastructure are particularly attractive residential locations.

5.2. Relationships Between WFH Index and Sub-Indicators

In the previous section, Figure 3 showed how the WFH index is spatially distributed and Section 4 presented the weights assigned to the WFH index components. Figure 4 now shows how the components and the final index are interrelated. Broadband access is strongly positively correlated with the WFH index. This outcome is in part explained by the minimum cut-off condition requiring broadband to reach 50 Mbit/s for at least 90% of a municipality's households, otherwise setting its WFH index to zero. The second-highest correlation—change in public accessibility—is associated with the stark interregional differences in public transport accessibility. This means that while wealthy municipalities benefit disproportionately from higher commuting allowances, less affluent ones do not have comparable public transport services. The lack of correlation between the WFH index and numbers of residents as well as jobs shows that size per se does not warrant attractive living conditions. It is hardly surprising that high house prices put off potential WFH workers.

To get a further feel for the data, Figure 5 plots the WFH index values against the distance to CBD Munich. The observations are coloured according to their

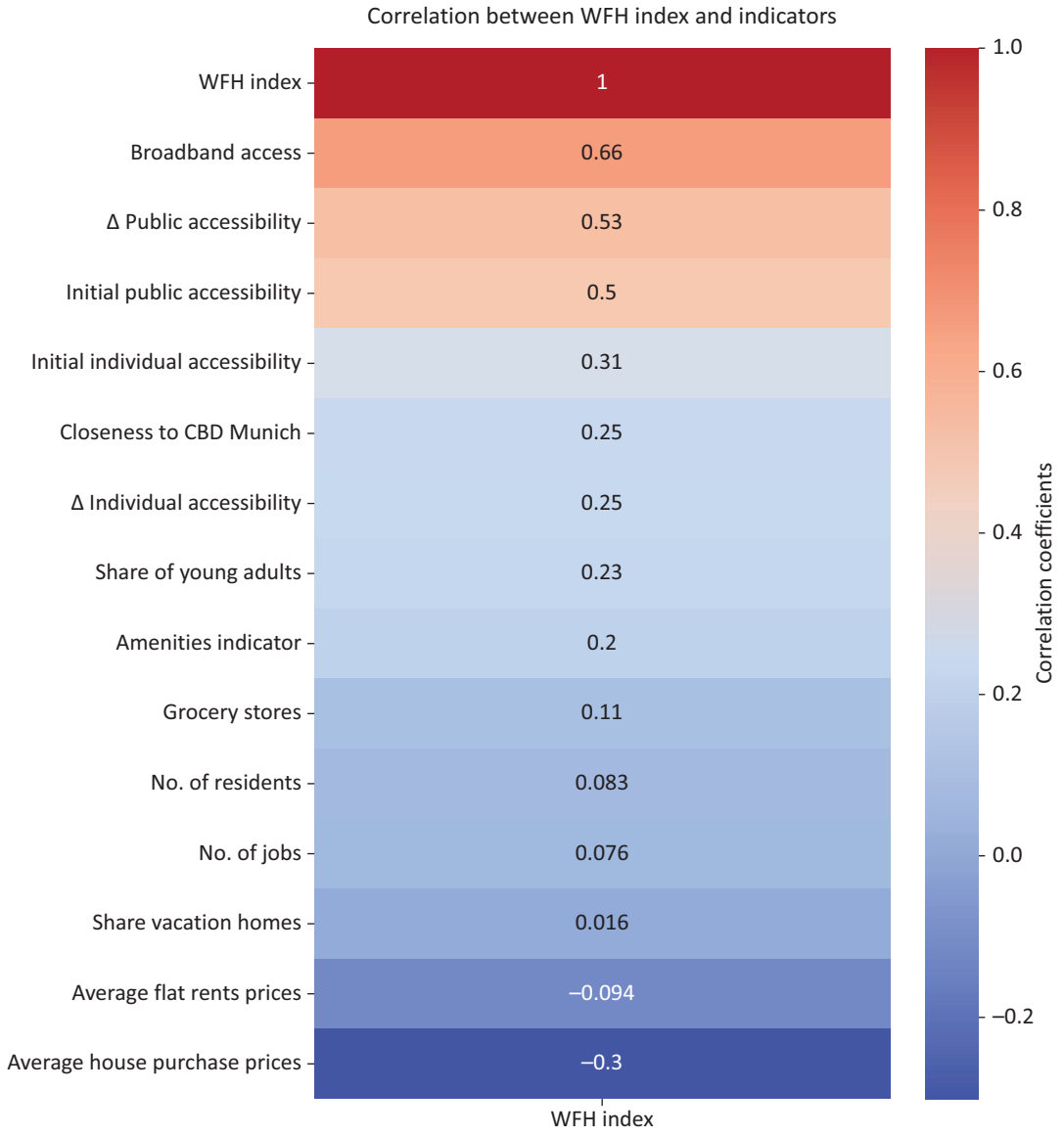

Figure 4. Correlations between WFH index and sub-indicators in the MMR.

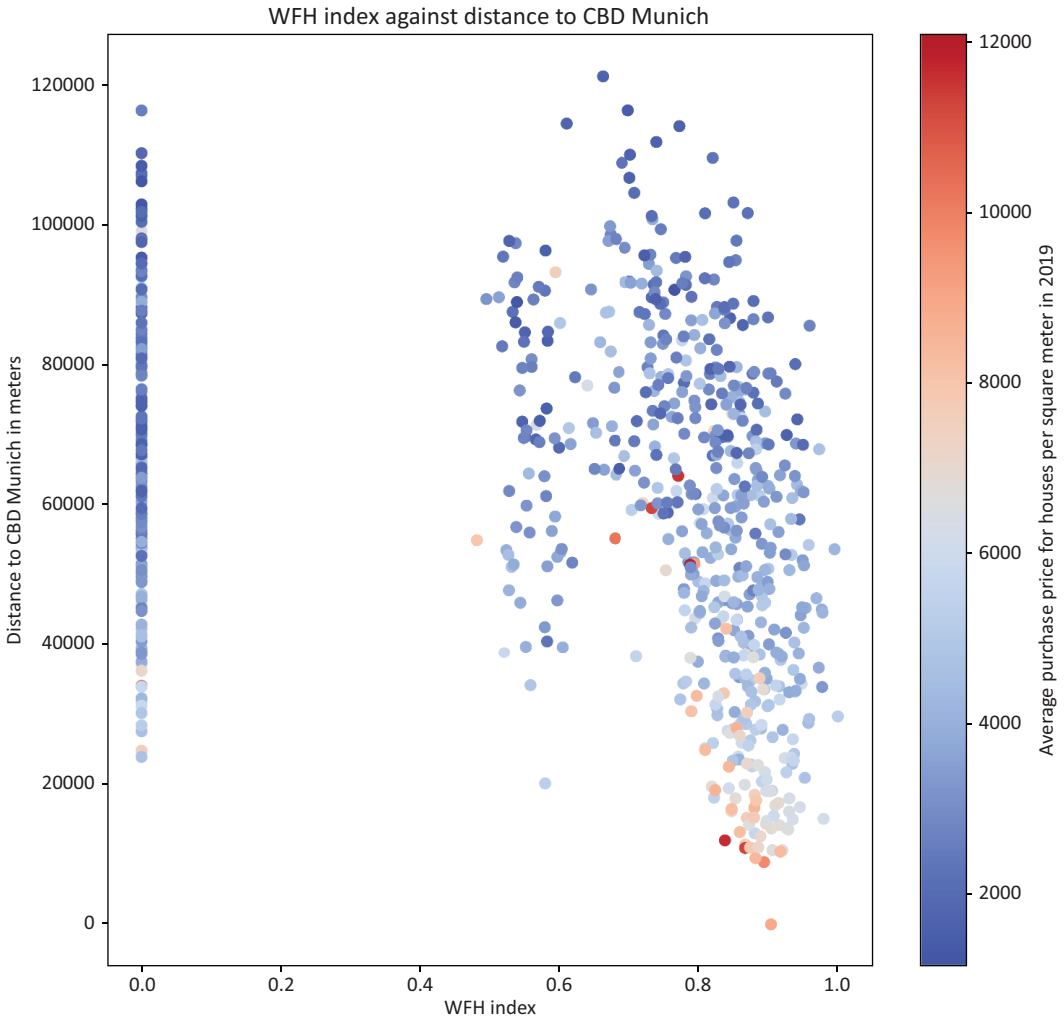

Figure 5. WFH index against distance to CBD Munich.

respective average house prices per square meter in 2019. It is evident that the best-performing municipalities are close to CBD Munich and are also relatively expensive. The municipalities that are furthest away from CBD Munich are also the most affordable ones.

Figure 5 shows that the advantage of living close to the MMR core is not offset by high housing costs when commuting to work on average 2.5 days per week.

6. Sensitivity Analyses

In this section, we test the robustness of our results. We first check for the changes in the outcomes associated with differing numbers of commuting days per week. Second, we test the impacts of choosing varied weights for the components of the WFH index.

6.1. Number of Commuting Days

Assuming that each individual is willing to spend a constant amount of time commuting per week, the accessibility of the municipalities changes depending on the number of commuting days per week. In the main scenario in Figure 3, we assumed 2.5 days of commuting per week. Zero days commuting is excluded from the analysis because this would allow working from anywhere. We construct six different scenarios with a gradual reduction of the average number of commuting days per week to visualise the gradual outward-spreading alteration of the distribution of municipalities with potential for additional residential demand in the MMR.

Figure 6 shows the results geographically. The first variant "4 days" shows a concentric distribution of potentials clustered around the City of Munich. The outer border of the MMR is almost bare of any potential. There are more densely clustered potentials to the north of the City of Munich than to the south. A corridor-type spread of potentials only emerges along some of the more important transport axes, reaching as far as the larger cities such as Augsburg, Ingolstadt, Donauwörth, and Rosenheim. The appearance of "islands," i.e., isolated and dispersed potentials, is rare. All in all, this means that a slight reduction of the average office presence to four days does not have a strong enough impact as a push-out or centrifugal force to distribute the potentials in a meaningful way. Rather, the highlighted areas in

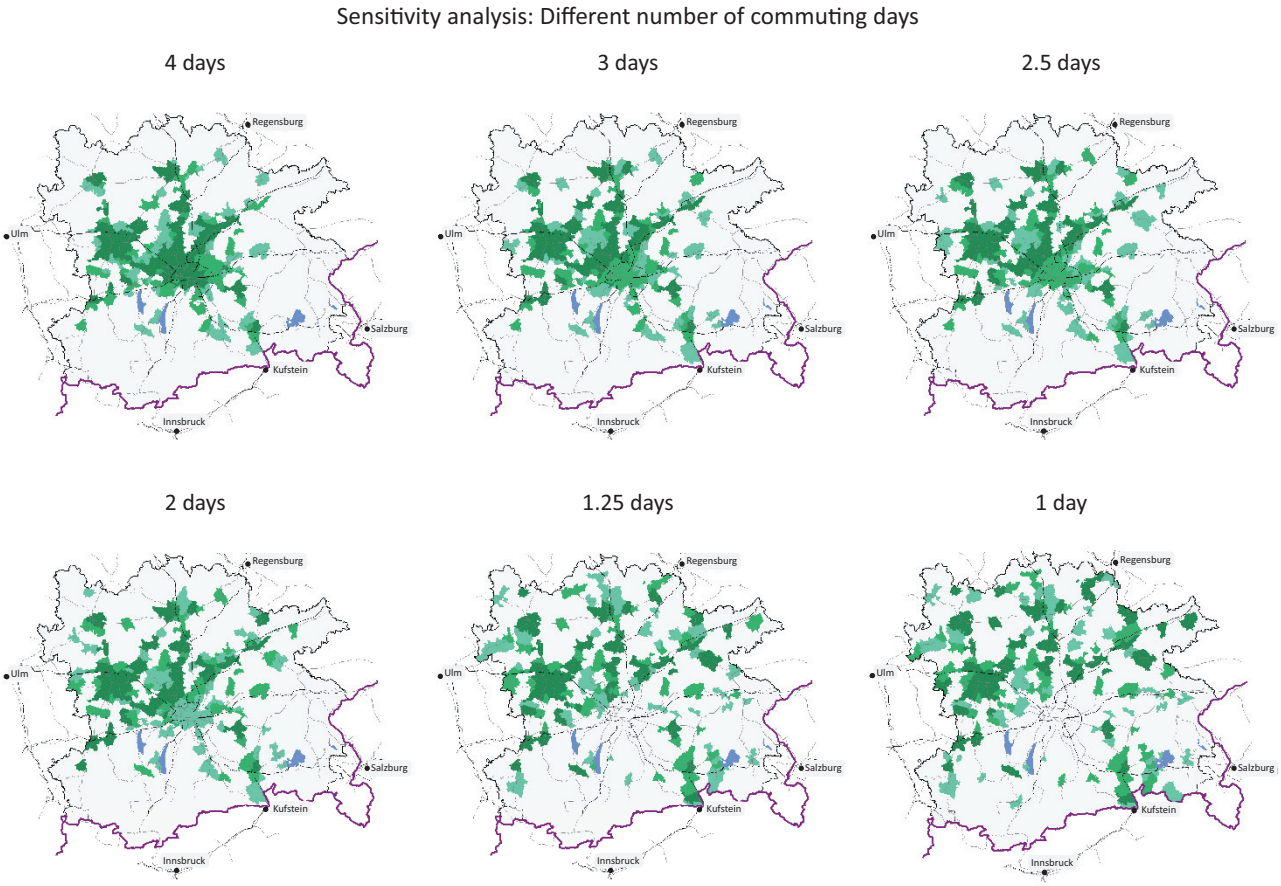

Figure 6. Sensitivity analysis with different β values that represent the change from five to fewer commuting days.

the map are similar to those that have already been destinations of suburbanisation in the past. Over the course of gradual reductions in the average number of commuting days, we observe (a) dissolution of the clustered potentials in the MMR's core around the City of Munich, (b) the City of Munich loses its potential only after a reduction to 1.25 days, (c) a significant increase in the formation of "islands," and (d) the municipalities towards the MMR's exterior border gain in potentials. Comparing the most extreme scenarios "4 days" and "1 day" of average commuting inspires the thought experiment of an explosion of a "clump of potential," by which the dominance of the core is replaced in such a way that the periphery takes over the core's initial shares of potentials. This exercise of sensitivities yields the main insight that the less often an individual commutes to work per week, the more likely it is that they will settle further away from their workplaces, which are spatially clustered in the core. Less office presence enables people to leave crowded, highly accessible, residential areas that are characterised by high prices for rent or real estate. Our premise, which is that people that commute rarely (such as one or 1.25 days in our example) tend to exhibit a much greater willingness to spend commuting time, is in line with the findings of de Vos et al. (2018). According to these sensitivities, WFH could on the one hand contribute to urban sprawl, but on the other hand to an easing of housing price differences across the region. However, for significant sprawl to take place in the MMR, the average number of commuting days would have to fall to less than two days a week.

The stability of the ranks in the WFH index between the different variants does not become clear from the maps in Figure 6. Consider, therefore, Figure 7, which compares the ranks of the WFH index variants with one, two, three, and four days of commuting per week with the main variant of 2.5 WFH days per week. In the total of five scenarios, a municipality can feature at most five times in either one of the three potential categories "high," "medium," or "low." The colours in the plots represent the number of occurrences in any of the potential categories without differentiating between the categories (i.e., assigning a counter with value "1" in each case). As discussed in Figure 6, the picture is quite stable with three almost perfect correlations in the cases of two, three, and four commuting days. A clear distinction emerges when commuting is reduced to one day per week, in which case the potentials are spread more unevenly across space. Due to the functional form of the accessibility measure

$$A_i = \sum_j \frac{W_j}{e^{\beta d_{i,j}}},$$

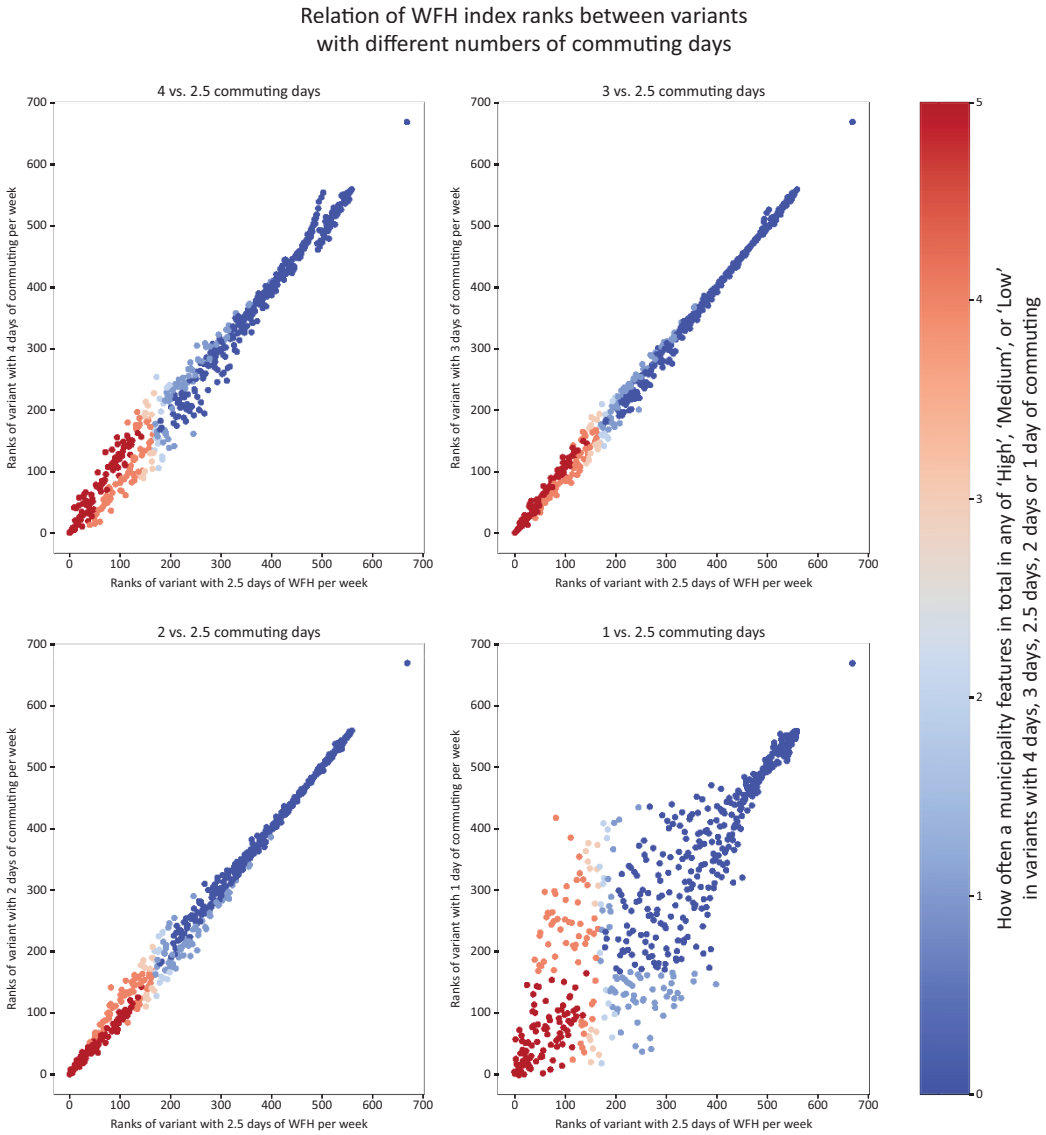

Figure 7. Sensitivity analyses with different β values that represent the change from five to fewer commuting days.

a reduction of β by x leads to a disproportionate, more than x increase in accessibility. Since the mechanism of the measured change in accessibility from five to less-than-five days of commuting per week is $\Delta A_i = A_i^{new} - A_i^{5\ days}$, the smaller β in A_i^{new} gets the disproportionately larger ΔA_i becomes. This is the technical implementation of the underlying logic that low commuting frequencies increase the willingness to spend more commuting time per trip. Finally, this translates into gradual reductions of the correlation between the main WFH index variant and those with lesser commuting frequency.

6.2. Weights per Indicator

In this section, we show how the overall index reacts to changes in its components. To visually assess the robustness of the WFH index when varying the weights, we present four new variants in Figure 8 and refer to Table 2 for the weighting of the variants.

In Variant 1, the weights of accessibilities are each reduced to increase the weights for housing costs. This configuration of the WFH index presents a picture of potentials more spread out towards the fringes of the MMR. Since housing prices in the MMR's core in Munich and neighbouring areas are significantly higher than elsewhere, this outcome does not come as a surprise. Instead, the areas around Donauwörth, Landshut, and Mühldorf gain in potential.

Variant 2 analyses which municipalities would pass the test of demanding WFH individuals who require a fast broadband connection (with 90% of households in a municipality connected to at least 100 Mbit/s instead of only 50 Mbit/s). Raising the minimum broadband capacity threshold leads to a thinning out of the total number of municipalities with potential from 168 down to 96. The result is basically a slimmed-down version of the main variant. Many of the "high" potential municipalities in the main version of the WFH index survive this broadband stress test and are still present in Variant 2.

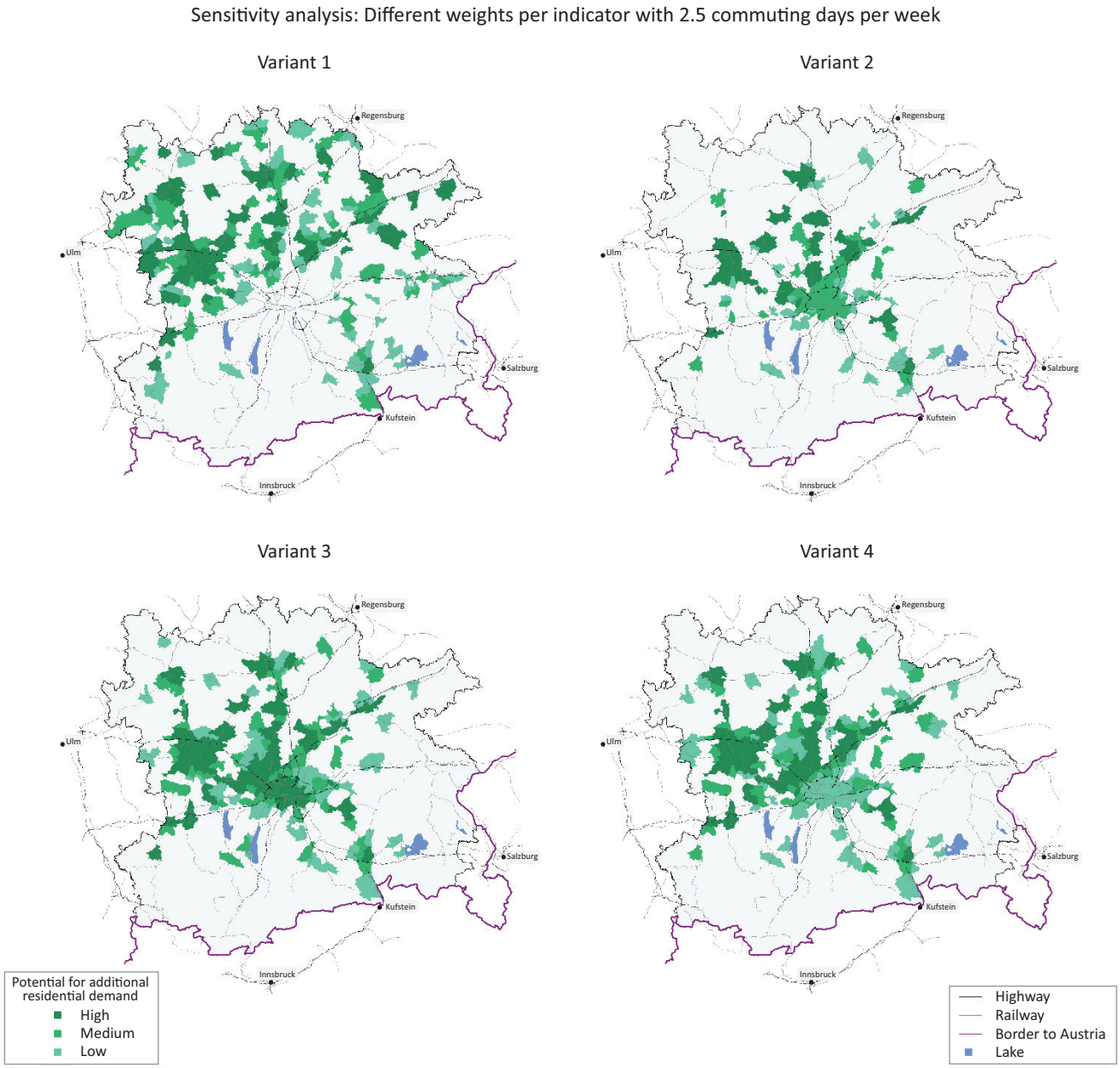

Figure 8. Sensitivity analyses with different weights of sub-indicators.

While urban agglomerations have introduced high-speed broadband, many rural areas did not do so at a comparable pace. Therefore, Germany is still characterised by a high regional variation in broadband availability (Gürtzgen et al., 2021).

Variants 3 and 4 suspend the previous equal weighting of public and individual transport accessibilities to identify different preferences of households between the usage rates of public and individual means of transport. Variant 3 weighs "public" more than "individual" and vice versa in Variant 4. The pictures reveal no significant changes apart from the City of Munich showing "high" potential in Variant 3 and "low" potential in Variant 4, again showing that the regional variation in public transport accessibility is a lot larger than for individual transport. Munich is highly accessible with many and frequently serviced public transport connections so that it outdoes more car-accessible municipalities. The other slight changes in potentials for smaller municipalities do not follow a systematic pattern.

In Figure 9, the rank correlation between the main WFH index variant with 2.5 WFH days per week, as explained in Section 4, and the four variants introduced above in this sub-section are shown with different modifications. The variants are plotted in the same order as in Figure 8. Similar to the map in Figure 8, the rank correlation for Variant 1 with higher housing weights shows the largest deviation. This proves that there are indeed significant regional disparities in housing costs. We decided against such heavy weights for housing costs because the decisive motivation for the WFH index is the mechanism of changing accessibilities through less commuting.

Table 2. Weights of WFH index variants in Figure 8.

	Alternative weights of components in WFH index								
	Accessibility		Housing costs		Internet	Cultural and natural amenities		Demography	Supply
Variant	Public	Individual	House purchase	Flat rentals	Broadband (min. speed: Mbit/s)	Amenities	Vacation homes	Young adults	Groceries
Main	25%	25%	10%	10%	15% (50)	5%	5%	2.5%	2.5%
1	15%	15%	20%	20%	15% (50)	5%	5%	2.5%	2.5%
2	25%	25%	10%	10%	15% (100)	5%	5%	2.5%	2.5%
3	30%	20%	10%	10%	15% (50)	5%	5%	2.5%	2.5%
4	20%	30%	10%	10%	15% (50)	5%	5%	2.5%	2.5%

The second variant with a higher broadband minimum threshold visualises the filtering out of all municipalities that fail to reach the threshold. Leaving those aside, the rank correlation is nearly perfect. Finally, Variants 3 and 4 are almost identical and both nearly perfectly correlated with the main variant.

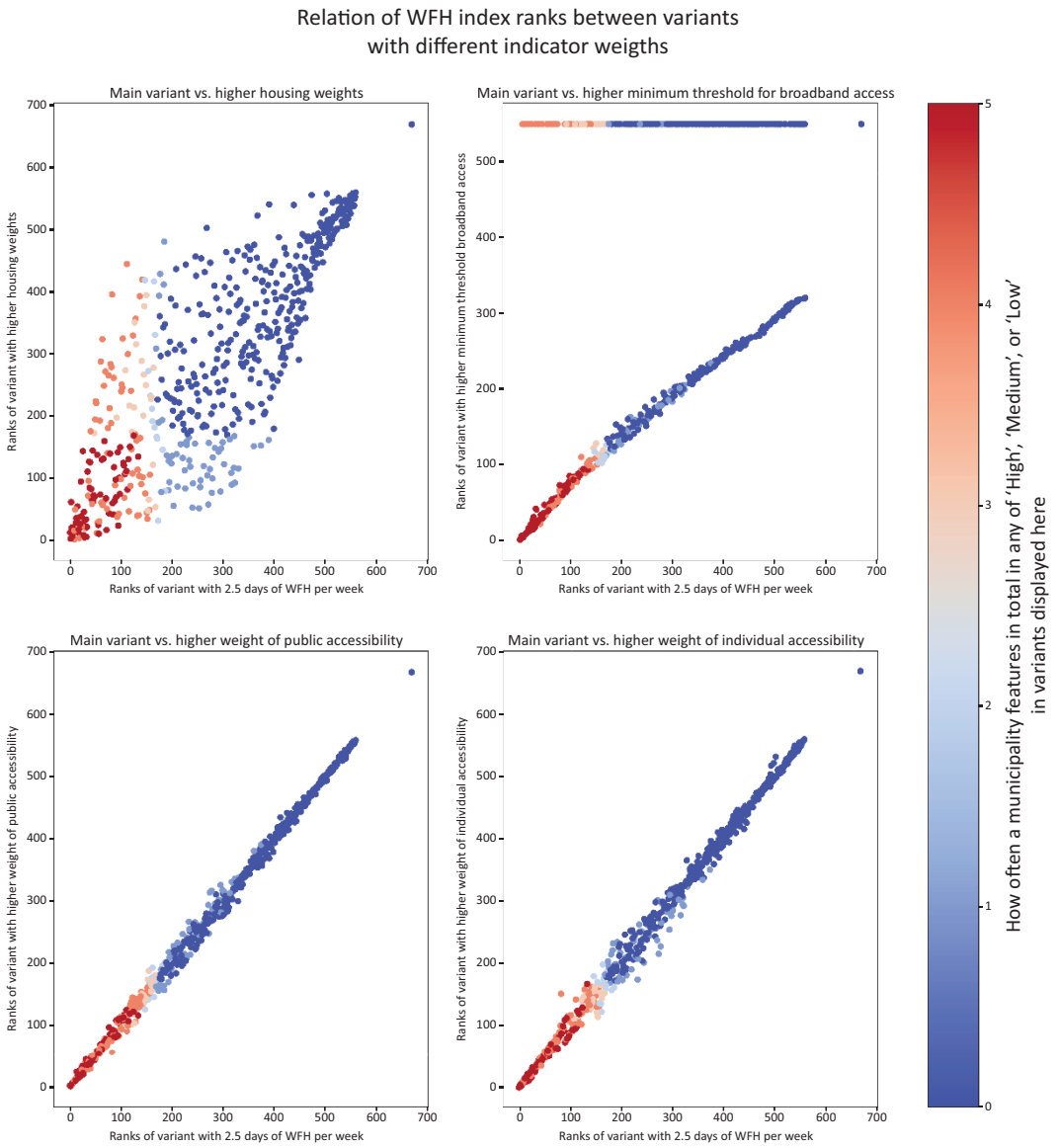

Figure 9. Sensitivity analyses with different weights of sub-indicators.

6.3. Functional Form

Delventhal and Parkhomenko (2021) argue that the disutility arising from commuting is only experienced on the days commuted to the job and therefore use the functional form $\beta e^{d_{i,j}}$ for the commuting cost. This form changes the commuting costs proportionately to changes in the distance decay β. Our employed functional form

$$A_i = \sum_j \frac{W_j}{e^{\beta d_{i,j}}}$$

causes disproportionate changes after alterations of β. This means that a doubling of β leads to more than a doubling of commuting cost. Inversely, as we associate $\beta = 0.035$ with five days of commuting, and for instance, $\beta = 0.0175$ with 2.5 days of commuting, this reduces commuting costs disproportionately with decreasing commuting frequency, which we argue for in a similar vein as de Vos et al. (2018), namely that the willingness for longer single commute trip durations increases with decreasing commuting frequencies.

6.4. Total Commuting Budget

An objection could be made against the assumption of keeping the total weekly commuting time budget constant. Rational agents would want to reduce both commuting frequencies and trip durations. To check this, we adjust the computation of the accessibilities such that we exclude relations that exceed one-way trip duration thresholds of 30, 45, 60, and 90 minutes respectively. An exclusion means that such *i*–*j* relations equal zero and thus do not increase municipality *i*'s accessibility. We plot the ranks of the WFH index without a maximum commuting budget (which is the main variant from Section 5) against the ranks of WFH indices with restrictions on one-way commuting trip durations as mentioned in Figure 10. It becomes evident that with decreasing trip duration thresholds, the correlation in ranks becomes less pronounced.

Overall, our sensitivity analyses allow us to estimate the robustness of our initial variant. The fundamental structure of the WFH index prevails, except for extreme configurations.

7. Comparison With First Evidence

In this section, we check the housing price developments after the onset of the Covid-19 pandemic. We use a more recent extension of the data set by the RWI—Leibniz Institute for Economic Research (Boelmann & Schaffner, 2021) that covers the period from April 2020 to June 2021. We group the observations by the WFH index categories "high," "medium," "low," and "no potential" as before. Observations from April to June 2020 are grouped together into "2. Quarter 2020" (second quarter of 2020) and observations from April to June 2021 make up "2. Quarter 2021" (second quarter of 2021). Observations are differentiated with respect to "house purchase prices," "flat purchase prices," "house rent prices," and "flats rent prices." We omit all observations that have non-unique identifiers to reduce the likelihood of errors. To establish comparability, we compute average prices per square meter. Therefore, we also omit all observations that have missing data on the number of square meters or price data. The results are presented in Figure 11.

The pattern is remarkable for house purchases. While all categories with potentials display positive slopes, the group without potentials has a negative slope. The steepest rise in prices occurred for the group with "high" potentials, overtaking "no potential" as the leader with the highest prices in 2021.

For flat purchases, the highest levels and the steepest rises are again in the group "high." The "medium" category displays the second-strongest increase in prices. "Low" and "no potential" have nearly identical slopes, but "no potential" is on average considerably more expensive.

When it comes to renting houses and flats, "high" is in both cases clearly the most expensive category. However, the steepest rise for renting houses appeared in the ranks of "medium." Again, "no potential" became cheaper. As for renting flats, "high" became cheaper by €0.72 per square meter on average. At the same time, all other three categories saw increasing prices for renting flats.

Taken together, this glimpse of short-term price developments after the onset of Covid-19 in Germany shows that the municipalities associated with favourable WFH conditions actually exhibited the strongest price increases, probably induced by higher demands. Purchase prices, in particular, have risen steeper than renting prices, which is in accordance with many recent public statistics and newspaper articles in Germany.

8. Implications for Spatial Planning

This study illustrates tendencies toward more metropolitan decentralisation in the wake of Covid-19, induced by a general shift to more WFH. We analyse which municipalities could gain in potential for additional residential demand. We established that the degree of decentralisation depends on the number of weekly commuting days, which becomes more discernible when this number decreases, and that significant decentralisation emerges with less than two commuting days on average.

From a planning perspective, the result is ambiguous. Decentralisation of residential demand within a metropolitan region could ease urban housing markets in the core, as Bauer et al. (2021) note, which is particularly relevant for the area studied. Conversely, stagnating peripheral municipalities may experience revitalisation (Horx, 2020), especially in light of the accelerated structural change in the retail sector (Adam & Klemme,

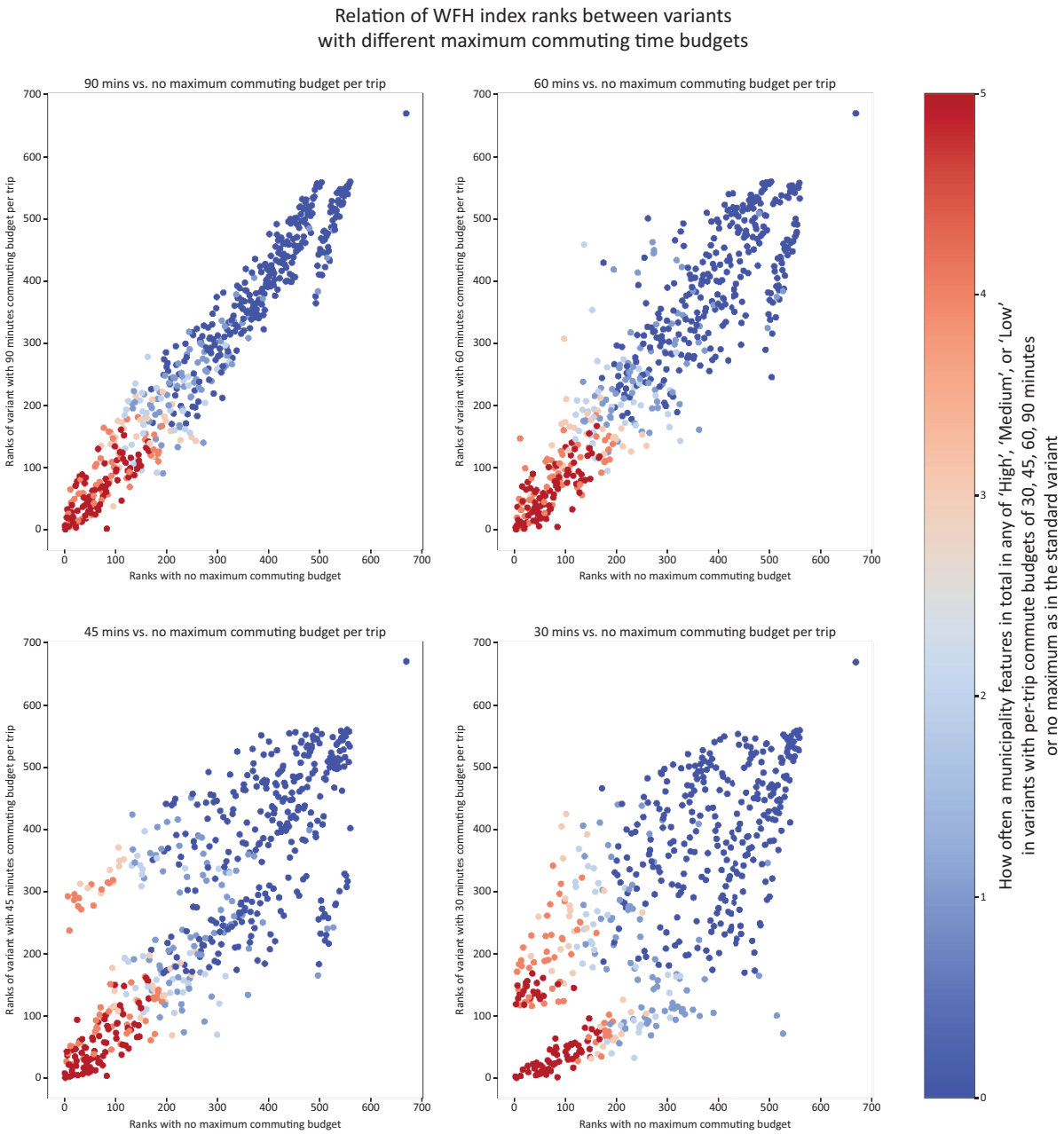

Figure 10. Comparison of rank correlations between WFH index variants with different commuting trip thresholds.

2020). Particularly recognisable is the potential in the "secondary cities" and their surrounding suburbs that might function as "substitutes" for the City of Munich by providing urban amenities together with affordable housing. Unlike more peripheral areas, they also offer residents favourable access to the City of Munich by public transport. Metropolitan planners thus have the opportunity of easing the strain on the core's density by strengthening Munich's urban surrogate cities. However, decentralisation endangers ecologically valuable green space through urbanisation. More dispersed settlements increase the share of cars among transport modes if the public transport infrastructure is left unchanged. This leads to higher greenhouse gas emissions and congestion. Furthermore, the inhomogeneous opportunities to work from home between different jobs threaten to exacerbate a socio-spatial divide because not all can reap the benefits of an extended set of options for residential choices.

Transit-oriented development offers an obvious option for a more resource-efficient adaptation to the new situation, especially where we identify underutilised public transport nodes or other local sub-centres in municipalities with potential in the WFH index. Where extant, urban brownfields could be reactivated. Pending a higher acceptance of public transport after the pandemic, transit-oriented development would ensure that at least a share of newly created traffic is more

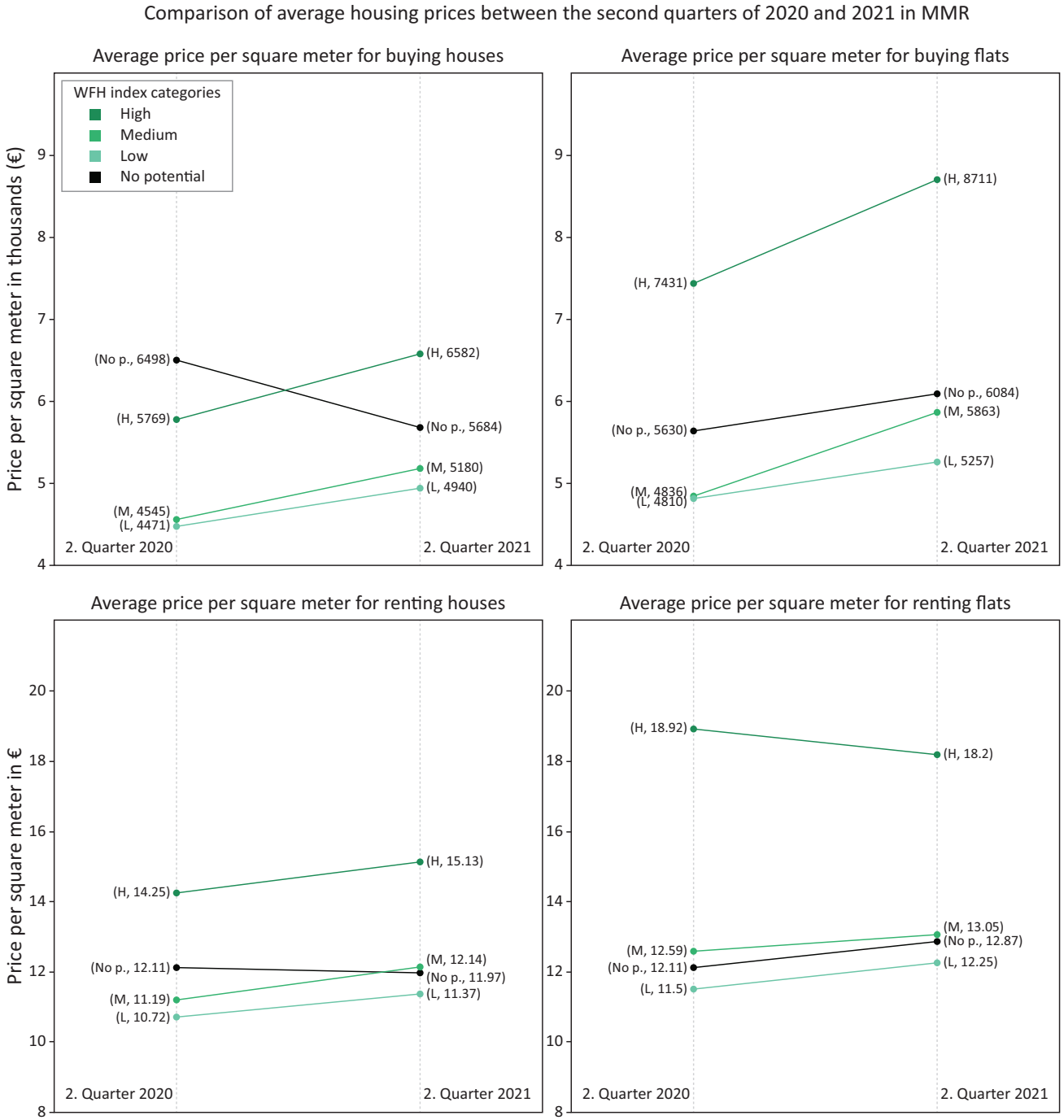

Figure 11. Comparison of average housing price developments from April–June 2020 to April–June 2021, differentiated according to WFH index categories. Notes: For "house purchases," there are 5,217 observations in 2020 and 3,566 in 2021; for "flat purchases" 6,675 observations in 2020 and 5,480 in 2021; for "renting houses" 1,671 in 2020 and 1,281 in 2021; and for "renting flats" 16,410 in 2020 and 18,994 in 2021. The WFH index categories are from the main variant, as explained in Section 4.

environment-friendly and space-saving than a development with a focus on individual transport. Co-working spaces at sub-centres may constitute a compromise between short commutes and physical separation of the places of residence and work. Importantly, digital capacities such as broadband networks must comply with high standards. Municipalities that face a loss of residents, in-commuters, and shopping customers could suffer from vacancies and the negligence of buildings' maintenance, thereby lowering residential appeal. This, in turn, facilitates a greater mix of land uses by attracting cultural, social, or non-profit activities as well as alternative forms of residential usage (Adam & Klemme, 2020). In line with prognoses from before the pandemic,

Kunzmann (2020) expects that retail stores will serve as mere physical displays for firms to entertain and inform customers rather than as places of selling, the process of which will take place online instead. A flexible and easily adjustable public space is important for a successful adaptation process. Particularly those individuals who cannot claim WFH are presented with an opportunity to render towns more attractive and affordable (Mallwitz, 2021).

9. Conclusion

This study was undertaken during the Covid-19 pandemic. That means that it is an ex-ante simulation without long-run ex-post evidence to test or verify the results. After the pandemic is over, in the medium and long run, it will be an interesting ex-post study to analyse residential movements in the light of locational factors. Our main result is that only a drastic reduction of commuting days per week for large shares of the working population would significantly alter the spatial distribution of residential demand. As this study is focused on an isolated, rather concentric metropolitan region, it ignores impacts from a wider spatial consideration. The natural consequence would therefore be to extend this examination to a national context. Fast, long-distance means of transport like high-speed rail facilitate commuting over longer distances. As there are larger price differences in real estate and housing rental markets nationally than within the MMR, WFH could entail a completely new dimension of the spatial distribution of residential locations. The residential adjustment process of households could entail second-round effects with firms adjusting their settlements. This would have far-reaching consequences on the urban fabric as offices and factories become abandoned and available for new usages. Finally, implementing an agent-based modelling approach to account for different types of persons that exhibit unique qualities regarding WFH possibilities and locational or lifestyle preferences could help to gain further insights into future residential patterns.

Acknowledgments

The authors thank the academic editor and the reviewers for their excellent remarks. The remarks helped in improving the communication of the WFH index and led to further examinations of relevant relations in the data. We also want to thank the participants of the special session "Covid-19 and Regional Resilience: Bouncing Back or Transforming Regional Economic Structures?" at the Annual Conference of the Royal Geographic Society—Institute of British Geographers 2021 for their vibrant discussion of the presented material.

Conflict of Interests

The authors declare no conflict of interests.

References

Adam, B., & Klemme, M. (2020). Die Stadt im Krisenmodus [The city in crisis mode]. *Informationen zur Raumentwicklung*, *47*(4), 4–15.

Agency for Digitisation, High-Speed Internet and Surveying. (2016). *Topographisches Informationsmanagement Bayern 2016* [Topographic information management Bavaria 2016] [Data set]. https://ldbv.bayern.de/produkte/dienste/geodatenonline.html

Ahlmeyer, F., & Wittowsky, D. (2018). What do we need in rural areas? How to use accessibility modelling as a strategy in transport planning. *Raumforschung und Raumordnung*, *76*, 531–550.

Alipour, J., Fadinger, H., & Schymik, J. (2021). My home is my castle: The benefits of working from home during a pandemic crisis. *Journal of Public Economics*, *196*, Article 104373.

Alipour, J., Falck, O., & Schüller, S. (2020). *Germany's capacities to work from home* (CESifo Working Paper No. 8227). Munich Society for the Promotion of Economic Research. https://www.cesifo.org/DocDL/cesifo1_wp8227.pdf

Alonso, W. (1964). *Location and land use*. Harvard University Press.

Althoff, L., Eckert, F., Ganapati, S., & Walsh, C. (2021). *The geography of remote work* (Working Paper No. 29181). National Bureau of Economic Research.

atene KOM. (2021). *Aktuelle Breitbandverfügbarkeit in Deutschland (Stand Ende 2020), Erhebung der atene KOM im Auftrag des BMVI* [Current broadband availability in Germany (as of late 2020), collected by atene KOM by order of BMVI] [Data Set].

Barrero, J., Bloom, N., & Davis, S. (2021). *Why working from home will stick* (Working Paper No. 28731). National Bureau of Economic Research.

Bartik, A., Cullen, Z., Glaeser, E., Luca, M., & Stanton, C. (2020). *What jobs are being done at home during the Covid-19 crisis? Evidence from firm-level surveys* (Working Paper No. 27422). National Bureau of Economic Research.

Batty, M. (2020). The Coronavirus crisis: What will the post-pandemic city look like? *Environment and Planning B: Urban Analytics and City Science*, *47*(4), 547–552.

Bauer, U., Gies, J., Hoch, A., Hollbach-Grömig, B., Kühl, C., Pätzold, R., Scheller, H., & Schneider, S. (2021). *Das Umland der Städte. Chancen zur Entlastung überforderter Wohnungsmärkte. Plausibilitäten–Determinanten–Restriktionen* [The hinterland of cities. Prospects of relief for overstrained housing markets. Plausibilities—Determinants—Restrictions]. Deutsches Institut für Urbanistik.

Berg, A. (2020). Homeoffice für alle? Wie Corona die Arbeitswelt verändert [Homeoffice for everyone? How Corona changes the working world] [PowerPoint presentation]. https://www.bitkom.org//sites/

default/files/2020-12/bitkom-charts-homeoffice-08-12-2020_final_0.pdf

Bick, A., Blandin, A., & Mertens, K. (2020). *Work from home after the Covid-19 outbreak* (CEPR Discussion Paper No. DP15000). Federal Reserve Bank of Dallas.

Boelmann, B., & Schaffner, S. (2021). *FDZ data description: Real-estate data for Germany (RWI-GEO-RED). Advertisements on the internet platform ImmobilienScout24* [Data set]. RWI – Leibniz-Institut für Wirtschaftsforschung. https://www.rwi-essen.de/forschung-beratung/weitere/forschungsdatenzentrum-ruhr/datenangebot/rwi-geo-red-real-estate-data

Boland, B., De Smet, A., Palter, R., & Sanghvi, A. (2020). *Reimagining the office and work life after Covid-19*. McKinsey & Company. https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/Organization/Our%20Insights/Reimagining%20the%20office%20and%20work%20life%20after%20COVID%2019/Reimagining-the-office-and-work-life-after-COVID-19-final.pdf

Brynjolfsson, E., Horton, J., Ozimek, A., Rock, D., Sharma, G., & TuYe, H. (2020). *Covid-19 and remote work: An early look at US data* (Working Paper No. 27344). National Bureau of Economic Research.

Bundesagentur für Arbeit. (2020). *Sozialversicherungspflichtig Beschäftigte am Arbeitsort 2019* [Employees subject to social insurance contributions at the place of work 2019] [Data set]. https://statistik.arbeitsagentur.de/SiteGlobals/Forms/Suche/Einzelheftsuche_Formular.html?nn=24280&topic_f=amk

Cho, S., Lee, J., & Winters, J. (2021). Employment impacts of the Covid-19 pandemic across metropolitan status and size. *Growth and Change*, *52*(4), 1958–1996.

Davis, M., Ghent, A., & Gregory, J. (2021). *The work-from-home technology boon and its consequences* (Working Paper No. 28461). National Bureau of Economic Research.

De Fraja, G., Matheson, J., & Rockey, J. (2021). *Zoomshock: The geography and local labour market consequences of working from home*. SSRN. http://dx.doi.org/10.2139/ssrn.3752977

de Vos, D., Meijers, E., & van Ham, M. (2018). Working from home and the willingness to accept a longer commute. *The Annals of Regional Science*, *61*(2), 375–398.

Delventhal, M., & Parkhomenko, A. (2021). *Spatial implications of telecommuting*. SSRN. http://dx.doi.org/10.2139/ssrn.3746555

Deutsche Bahn. (2021). *Rail schedule* [Data set]. www.bahn.de

Dingel, J., & Neiman, B. (2020). How many jobs can be done at home? *Journal of Public Economics*, *189*, Article 104235.

Discounto. (2021). *Supermarkets in Germany* [Data set]. https://www.discounto.de/Suchindex/Filial-Standorte-Postleitzahl

Dustmann, C., Fitzenberger, B., & Zimmermann, M. (2018). *Housing expenditures and income inequality* (SOEPpaper No. 1009). DIW Berlin. https://www.diw.de/de/diw_01.c.612259.de/publikationen/soeppapers/2018_1009/housing_expenditures_and_income_inequality.html

Elias, J. (2020, December 14). Google CEO delays office return to next September, but axes idea of permanent remote work. *CNBC*. https://www.cnbc.com/2020/12/14/google-ceo-email-delays-return-to-sept-2021-no-permanent-remote-work.html

Felstead, A., & Jewson, N. (1999). *In work, at home: Towards an understanding of homeworking*. Routledge.

Florida, R., Rodríguez-Pose, A., & Storper, M. (2021). Cities in a post-Covid world. *Urban Studies*. Advance online publication. https://doi.org/10.1177/00420980211018072

Glaeser, E. (2022). Urban resilience. *Urban Studies*, *59*(1), 3–35.

Gürtzgen, N., Diegmann, A., Pohlan, L., & van den Berg, G. (2021). Do digital information technologies help unemployed job seekers find a job? Evidence from the broadband internet expansion in Germany. *European Economic Review*, *132*, Article 103657.

Haag, M. (2020, May 12). Manhattan faces a reckoning if working from home becomes the norm. *The New York Times*. https://www.nytimes.com/2020/05/12/nyregion/coronavirus-work-from-home.html

Horx, M. (2020). Die Städte von morgen [The cities of tomorrow]. *Informationen zur Raumentwicklung*, *47*(4), 118–125.

Hoshino, T. (2011). Estimation and analysis of preference heterogeneity in residential choice behaviour. *Urban Studies*, *48*(2), 363–382.

Keil, R. (2020). The space and time a pandemic makes. *disP—The Planning Review*, *56*(3), 4–9.

Kim, J., Pagliara, F., & Preston, J. (2005). The intention to move and residential location choice behaviour. *Urban Studies*, *42*(9), 1621–1636.

Kinigadner, J., Wenner, F., Bentlage, M., Klug, S., Wulfhorst, G., & Thierstein, A. (2016). Future perspectives for the Munich Metropolitan Region: An integrated mobility approach. *Transportation Research Procedia*, *19*, 94–108.

Kolko, J. (2012). Broadband and local growth. *Journal of Urban Economics*, *71*(1), 100–113.

Kunzmann, K. (2020). Smart cities after Covid-19: Ten narratives. *disP—The Planning Review*, *56*(2), 20–31.

Lord, P. (2020). The social perils and promise of remote work. *Journal of Behavioral Economics for Policy*, *4*, 63–67.

Mallwitz, G. (2021, June 4). Homeoffice: Wo Kommunen Zuzug erwarten. Studie der TU München [Homeoffice: Where municipalities expect population influxes. Study from the TU Munich]. *Kommunal*. https://kommunal.de/corona-homeoffice-muenchen-wohnen-umland

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

Möhring, K., Naumann, E., Reifenscheid, M., Wenz, A., Rettig, T., Krieger, U., Friedel, S., Finkel, M., Cornesse, C., & Blom, A. (2021). The Covid-19 pandemic and subjective well-being: Longitudinal evidence on satisfaction with work and family. *European Societies*, *23*(Suppl. 1), 601–617.

Mongey, S., & Weinberg, A. (2020). *Characteristics of workers in low work-from-home and high personal-proximity occupations*. Becker Friedman Institute. https://bfi.uchicago.edu/working-paper/characteristics-of-workers-in-low-work-from-home-and-high-personal-proximity-occupations

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

OpenStreetMap Foundation. (2021). *OpenStreetMap* [Data Set]. www.openstreetmap.com

Orbis. (2021). *Orbis firm dataset* [Data set]. Bureau van Dijk. https://orbis.bvdinfo.com/version-20211216/orbis/Companies/Login?returnUrl=%2Fversion-20211216%2Forbis%2FCompanies

Prenzel, P. (2021). Are old regions less attractive? Interregional labour migration in a context of population ageing. *Papers in Regional Science*, *100*(6), 1429–1447. https://doi.org/10.1111/pirs.12627

Ramani, A., & Bloom, N. (2021). *The donut effect of Covid-19 on cities* (Working Paper No. 28876). National Bureau of Economic Research.

Rappaport, J. (2021). *Hybrid officing will shift where people and businesses decide to locate.* Federal Reserve Bank of Kansas City. https://www.kansascityfed.org/documents/7586/eb21rappaport0203.pdf

Reuschke, D., & Felstead, A. (2020). Changing workplace geographies in the Covid-19 crisis. *Dialogues in Human Geography*, *10*(2), 208–212.

Rosenthal, S. S., Strange, W. C., & Urrego, J. A. (2021). JUE insight: Are city centers losing their appeal? Commercial real estate, urban spatial structure, and Covid-19. *Journal of Urban Economics*, *127*, Article 103381. https://doi.org/10.1016/j.jue.2021.103381

Schröder, C., Entringer, T., Goebel, J., Grabka, M., Graeber, D., Kröger, H., Kroh, M., Kühne, S., Liebig, S., Schupp, J., Seebauer, J., & Zinn, S. (2020). *Vor dem Covid-19-Virus sind nicht alle Erwerbstätigen gleich* [Not all gainfully employed persons facing the Covid-19 virus are equal] (DIW Aktuell No 41). DIW Berlin. https://www.diw.de/de/diw_01.c.789505.de/publikationen/diw_aktuell/2020_0041/vor_dem_covid-19-virus_sind_nicht_alle_erwerbstaetigen_gleich.html

Shearmur, R., Ananian, P., Lachapelle, U., Parra-Lokhorst, M., Paulhiac, F., Tremblay, D., & Wycliffe-Jones, A. (2021). Towards a post-COVID geography of economic activity: Using probability spaces to decipher Montreal's changing workscapes. *Urban Studies*. Advance online publication.

Spellerberg, A., Neumann, U., & Eichholz, L. (2021). *Ergebnisse der Online-Befragung: Wandel beim Wohnen und im Wohnumfeld durch Homeoffice und Co-Working-Spaces* [Results of an online survey: Changes in dwelling attitudes induced by homeoffice and co-working spaces.]. Technische Universität Kaiserslautern. https://spellerberg-stadtsoziologie.de/images/Aktuelles/Tabellenband_Projektdokumentation_Corona_22_01_21.pdf

Stanton, C., & Tiwari, P. (2021). *Housing consumption and the cost of remote work* (Working Paper No. 28483). National Bureau of Economic Research.

Statistik Austria. (2021). *Gemeindeergebnisse der Abgestimmten Erwerbsstatistik und Arbeitsstättenzählung 2019 (Gebietsstand 2019)* [Results of synchronised statistics on employment and workplaces 2019 (Territorial boundaries as of 2019)] [Data set]. http://statistik.at/web_de/statistiken/menschen_und_gesellschaft/bevoelkerung/volkszaehlungen_registerzaehlungen_abgestimmte_erwerbsstatistik/index.html

Statistische Ämter des Bundes und der Länder. (2020). *German national census 2011* [Data set]. Zensus 2011. https://www.zensus2011.de/DE/Home/Aktuelles/DemografischeGrunddaten.html?nn=559100

Statistische Ämter des Bundes und der Länder. (2022). *Bevölkerung nach Geschlecht und Altersgruppen (17) Stichtag 31.12.—Regionale Tiefe: Gemeinden* [Population by age and sex (17)—Reference date 31.12.—Regional depth: Municipalities] [Data set]. Regionaldatenbank Deutschland. https://www.regionalstatistik.de/genesis/online?operation=statistic&levelindex=0&levelid=1642585750960&code=12411#abreadcrumb

Teaford, J. (2011). Suburbia and post-suburbia: A brief history. In N. Phelps & F. Wu (Eds.), *International perspectives on suburbanization* (pp. 15–34). Palgrave Macmillan.

Thierstein, A., Wulfhorst, G., Bentlage, M., Klug, S., Gilliard, L., Ji, C., Kinigadner, J., Steiner, H., Sterzer, L., Wenner, F., & Zhao, J. (2016). *WAM: Wohnen, Arbeiten, Mobilität. Veränderungsdynamiken und Entwicklungsoptionen für die Metropolregion München* [WAM: Living, working, mobility. Dynamics of change and options for development for the Munich Metropolitan Region]. Lehrstuhl für Raumentwicklung und Fachgebiet für Siedlungsstruktur und Verkehrsplanung der Technischen Universität München. https://mediatum.ub.tum.de/doc/1292926/file.pdf

Weinig, M., & Thierstein, A. (2021). Being close, yet being distanced: Observations on how the Covid-19 pandemic might affect urban interaction. *Town Planning Review*, *92*(2), 239–245.

About the Authors

Johannes Moser is a PhD researcher at the Technical University of Munich, currently investigating relations between high-speed rail and socioeconomic outcomes in Germany. He graduated with a BSc in economics from the University of Bonn and a MA in economic history from the University of Bayreuth. He is also interested in spatial consequences of exogenous shocks on residential patterns, such as the Covid-19 pandemic.

Fabian Wenner, Dr.-Ing., is a research and teaching associate at the Chair of Urban Development at the Technical University of Munich. His research focuses on integrated transport and urban development, land policy, and IT tools in urban planning.

Alain Thierstein, Dr. oec. HSG, is a full professor for urban development at the Department of Architecture of the School of Engineering and Design at the Technical University of Munich. He is involved in research on urban and metropolitan development; spatial impact of the knowledge economy, in particular the localised networks of firm relationships; the spatial interaction of locational choice of residence, work, and mobility; the spatio-functional interaction of rail infrastructure and urban development; and the role of star architecture for repositioning small and medium sized cities.