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The Role of COVID-19 in Spatial Reorganization: Some Evidence from Germany

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Abstract This paper analyzes the role of regional demographic, socioeconomic and political factors on changes in mobility during the COVID-19 pandemic. It provides new empirical evidence for the regional differentiation of lockdown measures and indicates a possible reorganization of spatial economic and social activities beyond the course of the pandemic. Spatial econometric models are analyzed using data from the 401 counties in Germany. Our results show that, for example, current high caseloads are negatively related to changes in mobility, whereas a region's socioeconomic composition and rural location have a positive effect. The political and economic implications of the findings are discussed.

Key words Economic geography, COVID-19 pandemic, lockdown, regional interaction, mobility, spatial econometrics

JEL R10, R11, R12

1 | Introduction

The COVID-19 pandemic is a major societal and economic challenge, with 152 million infections and 3.2 million deaths worldwide (as of May 2, 2021). Policymakers are responding with a wide variety of instruments, including in Germany: temporary closures of businesses, especially in the arts, entertainment and recreation, or hospitality sectors, suspension of compulsory attendance at schools, and repeated requests to increase use of home office options. In addition to restricting contacts, these measures also have the simultaneous effect of limiting mobility. In Germany, measures to restrict contacts were implemented for the first time in March 2020. Examples include direct mobility restrictions such as certain km radii around the place of residence, temporary entry restrictions to certain federal states or counties (Kreise), and (nighttime) curfews. Indirect mobility restrictions consist of repeated appeals to the population to avoid private and tourist travel, the closure of restaurants, cafés and leisure facilities and, eventually, self-motivation (caution and insight) to refrain from contacts and travel. From an economic point of view, therefore, a bundle of measures has increased the individual costs of mobility and, at the same time, reduced its attractiveness (utility).

How does mobility change in response to high infection rates and corresponding political measures? And on what other factors besides these measures and (possibly deterrent) COVID-19 case and death rates does this change in mobility depend? While mobility changes in times of the COVID-19 pandemic have been extensively analyzed in the literature at the individual, regional, or economy-wide level, this study asks two previously unanswered questions: First, what are the specific factors influencing mobility change in a regional context? In other words: What socioeconomic, geographic, and health factors are associated with changing mobility in the wake of the pandemic? Second, the question of spatial spillover effects of the mobility change per se arises. From a statistical perspective not considering these spatial interactions could bias the answer to our first question. Further, the spillover effects themselves are also of economic interest. This raises, for example, the question of learning effects from neighboring regions (positive spillover effects, "if mobility is reduced there, then we should reduce it here, too"), but also the opposite question of possible spatial substitution of mobility, i.e., whether the reduction of mobility in one county is replaced by an increase of mobility in the neighboring counties (negative spillover effects, "if the kin do not come to me, then I will just come to my kin").

These questions have far-reaching economic and political relevance. On the one hand, they can expand the still limited knowledge on the heterogeneous effectiveness of lockdown measures. Related to this is the question of deriving, for example, region-specific and thus more targeted measures than before, if it is known how which socioeconomic factors constrain or promote mobility change in the wake of COVID-19. In addition, the long-term, potentially spatially transformative effects are of particular interest (cf. Section 2).

Demographic, socioeconomic, and meteorological data as well as data on political COVID-19 measures (also at the county level) from various sources are used as covariates. These are supplemented by the regional COVID-19 case numbers provided by the Robert Koch Institute (RKI). Note that this study is based on the analysis of aggregated data (ecological study) with the associated limitations in terms of interpretation of the results, which also should be limited to the region level. A direct application of the results to the individual level can lead to so-called ecological fallacies, for which there are numerous examples in the literature. However, this only conditionally limits the relevance of our results, since the lockdown (and other policy) measures in question are also discussed solely at the regional level. The data are analyzed using the spatial autoregressive combined model (SAC). The location of the regions with respect to each other is captured by a weighting matrix. Note that these spatial models can reduce potential bias of ordinary least squares (OLS) estimation in the case of spatial spillovers and/or increase estimation efficiency.

The paper expands the existing literature on the spatial impact of COVID-19 in relation to several aspects. Schlosser et al. (2020) study the influence of the pandemic on the mobility of individuals. The authors stress that the pandemic has substantial influence on the mobility. They find that especially long-distance travel has been reduced strongly. Koenig and Dressler (2021) present results of a mixed-methods analysis of mobility changes in a German rural area. Their study analyses mobility data and survey data on the perceived changes of people based on a representative household survey. Linka et al. (2021) investigate the dynamics between mobility and COVID-19 operationalized by global air traffic and local mobility. Their study demonstrates different intensities of disease dynamics. For ten European countries there is a time lag between mobility and disease dynamics of around 14.6 days on average. Other examples of extant literature include Coven and Gupta (2020) or Bludau et al. (2020).

The paper is structured as follows. A brief overview of spatial theory is given in Section 2. The data used and the statistical methodology are presented in Section 3. A discussion of the empirical results follows in Section 4. Section 5 then relates these results to their spatial implications. Section 6 concludes.

2 | Theory of Spatial Structure

The spatial distribution of economic activities has been discussed in the principles of the classical theory of location such as von Thünen (1826), Weber (1909), or Lösch (1944) – just to mention a few. In general, economic and social development always have a spatial dimension. This importance is reflected in regional peculiarities, in differences in economic activities, or living conditions (Bröcker and Fritsch 2012). Spatial activity – and thus prosperity and economic action – is unevenly distributed. Exogenous and endogenous explanations can help to explain this fact.

The exogenous explanation takes the geographical conditions as given, companies and households adapt their behavior accordingly. There are also other characteristics that can be traced back to economic decisions, such as the locations of (supply) markets. Moreover, the endogenous explanations are reasons for a differentiated, unevenly distributed spatial structure of economic activities in a homogeneous area (without geographical differences). In addition to many differentiated approaches, the spatial costs are the basis of the geographic economy. Costs to overcome spatial distance must be lower than the benefits of an interaction (taking complementarity and no alternative opportunity costs into account). It can be plausibly assumed that spatial costs during a pandemic are higher for individuals (for a given technology). The benefits of home office are possibly greater than that of the open shared office. Avoiding public transport or other modes of transport increases benefits of organizing work at home.

The space overcoming costs arise when households and companies move goods, people and information in space. In addition to transport costs, we refer to all costs for overcoming space, including costs for transmitting communication. It is crucial that these costs have fallen massively in recent years in order to move goods, people and information through space over distances – sometimes around the globe. But these costs are still relevant. However, it should also be noted that although the transaction costs are steadily falling during the exchange, more information is exchanged – and this also over greater distances – than ever before (Bröcker and Fritsch, 2012).

The triggers for spatial differentiation – the juxtaposition of growing cities, metropolitan regions, and shrinking regions – are the interdependent location decisions of workers and companies. Ongoing globalization, the European integration process and technological progress – especially in the field of IT – have led to a continuous decline in transport and communication costs. This development facilitates the mobility of labor and capital, the dissemination of information, and the exchange of goods and services between regions. But, it also helps to reduce the costs of communication between employees of the same company, customers, and clients (e.g. virtual conference and meetings). The location ties of production factors and workers, but also families, have decreased. On average, companies settle where they find the most attractive location conditions. Workers and their families are migrating to regions that offer them attractive working and living conditions. Regions are permanently in intense competition for companies and qualified workers.

The question is how stable this equilibrium is and whether the framework will shift as a result of the pandemic and thus massively reduce the costs to overcome space through the intensively use of digital solutions.

3 | Data and Methods

3.1 | The Data

This analysis is a retrospective ecological study at the level of 401 counties (Kreise) in Germany, whose populations range from about 34,000 (Zweibrücken) to about 3,664,000 (Berlin). As an outcome variable, the study uses the change in general mobility behavior at the county level in January 2021 (average values are calculated separately for weekdays and weekends for the entire month from January 4 to exclude the influence of the New Year's weekend) compared to the same period of the previous year. The mobility data are provided by the Federal Statistical Office (2021). To map mobility at the district level, anonymized mobile communications data from the network of the communications provider Telefónica (Germany-wide market share ≥ 30%) are used, which are processed and made available by Teralytics. The data provides an overview of the number of mobile devices performing a certain movement. Movements are recorded when a mobile device changes the cell. The target region of a movement is reached when the mobile remains in a cell for at least 30 minutes. Deviations in relation to the total population may occur due to the provider's regional market shares, which are, however, partially compensated for by the provider using an algorithm based on geographic differentiated market shares.[1]

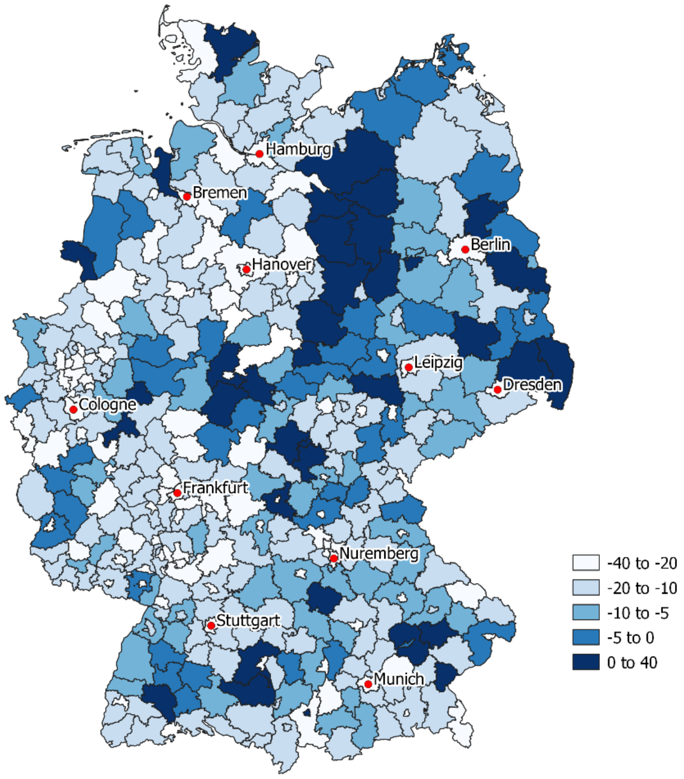
As a target variable for the analysis, data provided by the Federal Statistical Office on mobility change between January 2021 and January 2020 are analyzed at the county level (cf. Fig. 1). Note that a decline in mobility was observed in most of the regions. However,

[1] See https://www.destatis.de/DE/Service/EXDAT/Datensaetze/mobilitaetsindikatoren-mobilfunkdaten.html for details.

the former border areas between Lower Saxony on the one hand and Saxony-Anhalt and Brandenburg on the other show increased mobility. The month of January 2021 was chosen as the core period of the second COVID-19 wave in Germany. In addition, the same month of the previous year, January 2020, was the month before the pandemic hit Germany (and the rest of the global economy).

In addition to the COVID-19 case numbers provided by the RKI at the county level, various socioeconomic, demographic, meteorological, political and health variables (including government restrictions on mobility) at the county level are used as covariates whose possible influence on (COVID-19-related) mobility change will be analyzed. An overview is provided in Table 1.

Figure 1: Mobility change on working days (Jan 2021 vs. Jan 2020) at county level



Source: infas 360 (2021).

Table 1: Basic sample characteristics

Variable	Mean	Median	SD	N
Change in mobility in %.	-13.274	-13.250	10.953	401
Cases Jan 2021 (per 100,000 inhabitants)	590.342	512.592	281.252	401
Cases Dec 2020 (per 100,000 inhabitants)	822.709	750.256	414.382	401
Deaths Jan 2021 (per 100,000 inhabitants)	23.144	18.502	17.550	401
Deats Dec 2020 (per 100,000 inhabitants)	31.669	24.733	25.020	401
Unemployment rate 2020	5.487	5.200	2.198	401
Unemployment rate Jan. 2021	5.908	5.600	2.215	401
Household income	1,872.561	1,869.000	215.765	401
Nursing home employees	97.709	96.800	23.279	401
Share of employed academics	11.958	10.300	5.170	401
Industry share	18.254	17.200	8.724	401
Service share	39.243	33.900	14.842	401
Tourist beds	41.776	27.000	49.309	401
Mean age	44.539	44.300	1.965	401
Women	50.597	50.600	0.645	401
Heart failure	3.845	3.530	1.420	401
COPD	6.455	6.400	1.503	401
Physicians	14.587	12.900	4.409	401
Pharmacies	27.004	26.100	4.900	401
People in need of care	428.125	424.200	106.029	401
Population density	533.748	198.000	702.713	401
Car density	579.160	593.000	70.980	401
Commuter balance	-10.362	-12.000	29.724	401
Share of foreigners	10.035	9.200	5.149	401
Rural (0/1)	0.339	0.000	0.474	401
Pupils	10.125	10.000	1.501	401
Childcare	32.269	28.800	12.077	401
Car travel time central city (Mittelzentrum)	6.786	8.000	5.548	401
Commute over 300km	2.402	2.200	0.892	401

In selecting the possible factors influencing mobility change, we largely followed the existing literature and the following substantive arguments:

- Case numbers previous month: People remember infection events, align their behavior accordingly with a time lag.
- Deaths: It can be assumed that the deterrent effect (also in the media) is particularly large.
- Unemployment rate: This has both direct (fewer trips to work) and indirect effects (search activities, less financial scope for trips) on mobility.
- Household income: The level of income is correlated with job and place of residence. When analyzing the modal shift, Koenig and Dressler (2021) showed

that the number of car trips is significantly associated with a higher net household income.

- Nursing home employees: It is of particular interest whether there is leeway in outpatient care to restrict mobility.
- Employment/industry structure: It is expected that home office will be more feasible for employees in the service than in the industry sector. Therefore, regions with a high industrial share will presumably be less affected by a decline in mobility.
- Health variables: Several studies suggest that pre-existing conditions including hypertension, lung diseases, respiratory diseases and heart failures significantly increase the risk of a severe course of a COVID-19 infection or death (Guan et al. 2020; Guo et al. 2020; Ssentongo et al. 2020). Due to the wide disclosure of those research results people with such pre-existing conditions are more likely to decrease their mobility.
- Demographic variables: Demographic variables (mean age, woman, share of foreigners) are relevant in the context of employment and mobility. In Germany, for example, due to the pandemic, the unemployment rate for men (from 5.3% to 6.7%) increased slightly more than that of women (from 4.9% to 5.9%). At the same time, foreigners (from 12.1% to 15.5%) are much more affected than Germans (from 4.1% to 5.1%) (reference month July 2019 and July 2020) (Nitt-Drießelmann et al. 2020). Due to the higher proportion of foreigners among the low and medium-skilled employees, it may be expected that mobility among this group will decrease less sharply.

3.2 | Methods

What influences the COVID-19-related change in mobility at the county level and how can the influence of non-COVID-19-related circumstances be at least partially accounted for? Since this research is forced to be a historically controlled study, the question of changed concomitant circumstances that would have varied on an annual basis even in the absence of the COVID-19 pandemic and thus cannot be attributed to the pandemic must be carefully considered. The potential bias will be only partially avoidable from a statistical perspective but will be mitigated by the comprehensive covariates (variance in area, i.e., their possible influence on the changed accompanying and living circumstances). Conceivable biasing factors include general trends in regional mobility, holiday effects, and the influence of weather on mobility (e.g., for excursions). The last point is taken into account by the separate analysis of weekdays and weekends, as well as the inclusion of differences in sunshine duration and temperature between January 2021 vs. 2020 (whereby mobility in the month of January is certainly less influenced in this respect than in the summer months, so that some general robustness can be assumed for the study period). Furthermore, holiday effects are already taken into account in the data preparation by the Federal Statistical Office (2021). General trends in mobility over time are accounted for, at least indirectly, by its relation to socioeconomic variables and, of course, by the inclusion of a constant term.

Taking the above constraints into account, our identification strategy works as follows. We assume that the mobility change is driven, on the one hand, directly by contact and mobility restriction policies such as, in particular, contact restrictions in public space, wholesale and retail restrictions, restrictions in the tourism sector, and curfews. Our corresponding variables (see Table 1) reflect whether or not these restrictions were in effect on a given day in January 2021. On the other hand, we assume that mobility change is driven indirectly by the COVID-19 case numbers (e.g. people adjust their lifestyle after being repeatedly encouraged to do so by policy makers) in addition to the above policy measures. We thus assume that regional heterogeneity of case numbers serves as a central COVID-19-related parameter influencing mobility. We also test the additional hypothesis that not only COVID-19 case numbers have an impact on mobility, but that this impact is moderated by socioeconomic covariates (interaction effects).

In contrast to a standard linear model (OLS), our analysis takes into account the spatial distance of the observation units (counties) from each other. Spatial statistical models (see below) are then able to reflect the fact that outcomes in one region may be influenced by outcomes in neighboring regions (spatial spillover effects) and/or a spatial autocorrelation of the residuals. This proposition can be explained, e.g., via learning effects from neighboring regions or, in contrast, spatial substitution of mobility. In the latter case reduced mobility in one region is quasi-substituted by increased mobility in neighboring regions, see the discussion in Section 1.

The spatial statistical models capture the neighborhood relationships using a so-called spatial weighting matrix (i.e., a symmetric N×N matrix). This is based here on the geocodes (longitude and latitude of the circle centers) provided by the provider Opendatasoft (under the Creative Commons license). Specifically, the spmatrix command in Stata/MP 16.1 was used to create an inverse distance matrix from the coordinates, in which regions closer to each other are given a higher weight. The technical details of the spatial statistical models shall be omitted here with reference to the detailed discussion in Elhorst (2014).

4 | Results

The data analysis was performed using the spregress command in Stata/MP 16.1. Table 2 shows the results for the SAC model, which we focus on here, because it includes the spatial autoregressive and spatial error models as special cases.[2] Before discussing the individual coefficient estimators, we briefly note the LR test vs. the OLS model at the bottom of the table. This does not support the use of a spatial SAC model because the null hypothesis of an OLS model cannot be rejected.

Table 2 contains results for the change in mobility on weekdays (January 2021 versus January 2020) in the left-hand three-column block and results for weekends (in January 2021 versus January 2020, excluding the New Year's weekend) in the right-hand block. In each case, the coefficient estimators, standard errors, and p-values are given. Dummies for the 16 states were included (not shown) in the estimation to account for the influences of state-specific COVID-19 measures (for which no reliable database is available).

Starting with the estimation results for weekdays, the significant negative association between the average (population-standardized) case numbers in January 2021 and the mobility change can be noted first. Both the previous month's caseload and death rates show no significant association with changes in mobility behavior, disproving the (time-lagged) deterrent effect hypothesis discussed in Section 3.1. The unemployment rate shows a time-delayed effect reversal. The average unemployment rate in the previous year has a significantly positive impact on mobility behavior, while the contemporaneous unemployment rate in January 2021 has a significantly negative impact. On the one hand, a time-delayed higher mobility due to the search activities for a new job can be discussed as an explanation. Note that with regard to the negative coefficient of January 2021 unemployment, endogeneity cannot be ruled out either, as (forced) reduced mobility can also have simultaneous negative effects on the labor market. The share of graduates and the share of service providers clearly show a significant negative association with changes in mobility. This can be explained in particular by the higher home office rates in service occupations, which often require a higher level of education.

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[2] The results for the latter two models are not reported, but are very similar to those in Table 2.

Table 2: Estimation results
(Dummy variables for the federal states were included, results not shown).

	Weekdays			Weekends		
Coefficient estimates	**Coef.**	**Std. Err.**	**P>|z|**	**Coef.**	**Std. Err.**	**P>|z|**
Cases Jan 2021 (per 100,000 inhabitants)	**-0.009**	**0.004**	**0.016**	**-0.009**	**0.004**	**0.028**
Cases Dec 2020 (per 100,000 inhabitants)	-0.003	0.002	0.268	-0.003	0.003	0.264
Deaths Jan 2021 (per 100,000 inhabitants)	0.062	0.040	0.127	0.059	0.047	0.212
Deats Dec 2020 (per 100,000 inhabitants)	0.024	0.032	0.447	0.022	0.037	0.561
Unemployment rate 2020	**4.522**	**1.995**	**0.023**	**5.160**	**2.328**	**0.027**
Unemployment rate Jan. 2021	**-4.342**	**1.897**	**0.022**	**-4.643**	**2.213**	**0.036**
Household income	**0.005**	**0.003**	**0.127**	**0.007**	**0.004**	**0.067**
Nursing home employees	0.027	0.026	0.308	0.033	0.031	0.278
Share of employed academics	**-0.512**	**0.164**	**0.002**	-0.043	0.191	0.823
Industry share	-0.017	0.068	0.805	0.034	0.079	0.671
Service share	**-0.206**	**0.075**	**0.006**	**-0.232**	**0.087**	**0.007**
Tourist beds	-0.002	0.011	0.868	-0.008	0.013	0.513
Mean age	**1.033**	**0.545**	**0.058**	**1.213**	**0.638**	**0.057**
Women	-1.293	0.856	0.131	**-1.801**	**0.992**	**0.069**
Heart failure	0.201	0.483	0.678	0.423	0.569	0.457
COPD	**-0.937**	**0.401**	**0.019**	**-1.164**	**0.470**	**0.013**
Physicians	-0.166	0.233	0.477	0.110	0.271	0.686
Pharmacies	-0.199	0.122	0.102	**-0.276**	**0.142**	**0.052**
People in need of care	**0.020**	**0.008**	**0.014**	**0.031**	**0.009**	**0.001**
Population density	-0.001	0.001	0.387	-0.001	0.002	0.349
Car density	**-0.021**	**0.012**	**0.073**	**-0.028**	**0.013**	**0.039**
Commuter balance	0.024	0.032	0.450	-0.004	0.038	0.924
Share of foreigners	**0.461**	**0.186**	**0.013**	0.276	0.218	0.206
Rural (0/1)	**2.598**	**1.084**	**0.017**	1.368	1.282	0.286
Pupils	-0.366	0.380	0.335	0.041	0.435	0.924
Childcare	0.082	0.101	0.414	0.091	0.117	0.436
Car travel time central city (Mittelzentrum)	**-0.227**	**0.124**	**0.067**	-0.129	0.144	0.372
Broadband coverage	**-0.082**	**0.043**	**0.059**	**-0.121**	**0.050**	**0.017**
Commute over 300km	**-1.555**	**0.753**	**0.039**	**-1.855**	**0.882**	**0.035**
Diff. hours of sunshine	-0.032	0.041	0.438	-0.021	0.048	0.670
Diff. temperature	1.462	1.451	0.314	0.165	1.723	0.923
Contact restrictions in public space (0/1)	5.347	6.301	0.396	10.648	7.417	0.151
Wholesale & Retail Restrictions (0/1)	34.673	40.499	0.392	29.434	47.063	0.532
Restrictions in tourism sector (0/1)	4.361	6.518	0.503	10.100	7.640	0.186
Curfews (0/1)	0.117	5.205	0.982	-6.148	6.067	0.311
Cases Jan 21 x mean age	0.001	0.001	0.381	0.000	0.001	0.761
Cases Jan 21 x academics	0.000	0.001	0.908	0.000	0.001	0.624
Cases Jan 21 x pop. dens.	0.000	0.000	0.659	0.000	0.000	0.518
Cases Jan 21 x rural	0.003	0.003	0.259	0.002	0.003	0.593
spatial lag	0.318	0.196	0.104	0.040	0.254	0.875
spatial autoregressive error	-0.268	0.595	0.652	0.079	0.594	0.894
LR chi2 (OLS)	2.480		0.290	0.070		0.966
Log likelihood	-1,329.553			-1,390.221		

The average age at the county level is significantly positively related to the mobility change, which can be explained, among other things, by the lack of influence of home office and homeschooling for older persons. The regional share of women shows a significant negative association with mobility trends. One plausible reason may be the higher share of home offices in the service professions, the majority of which are held by women.

Among the health variables, only the COPD proportion seems to have a significant (negative) influence on the mobility change. Since this is a direct risk group in connection with a potential COVID-19 infection, personal precautionary motives may serve as a plausible explanation. In contrast, the number of persons in need of care has a significant positive coefficient. Since the data do not differentiate between institutional and home care, this result may simply reflect the lack of opportunity to substitute mobile outpatient care.

Car density reveals a significantly negative coefficient. A high car density can also be seen as an indicator for a high potential of mobility reduction (e.g. cars used for commuting to work). An analogous argument applies to the significant negative coefficient of the share of commuters with more than 300km to work. In addition, the significant positive coefficient of rural regions is to be discussed. Here, the argument of a higher mobility requirement or higher costs of mobility avoidance for reasons of provision of general interest (shopping, commuting to work, medical care) applies. As expected, higher broadband coverage, which is a prerequisite for reliable remote work, for example, will have a significant negative impact on the change in mobility.

The potential influence of temperature and sunshine duration on the change in mobility discussed in Section 3.2 remains insignificant for both weekdays and weekends. However, it must be emphasized that these are monthly average values, whose distribution on weekdays or weekends was not differentiated. Interestingly, direct political restrictions on mobility have no significant effect on the change in mobility. In this context, it should be noted that the regional heterogeneity of these restrictions (with the exception of curfews) is rather low in the period under review (January 2021), see Table 1. Interactions (moderator effects) were included for the January 2021 case numbers with average age, share of academics, population density, and rural location. They all turn out to be insignificant.

It is interesting to compare the estimated coefficients between weekdays and weekends. For example, in contrast to weekdays, household income on weekends shows a lower level of significance with respect to its positive relationship with mobility change. This may reflect more diverse opportunities for mobile leisure activities with higher income, which can be realized with some financial effort despite the COVID-19 restrictions (day tourism, camping). The negative effect of the share of academics on mobility (on weekdays) discussed above disappears when looking at weekends. This seems plausible with reference to high home office shares among academics, which play a minor role in leisure time on weekends. Looking at the share of foreigners, weekends (in contrast to weekdays, where it is significantly positive) show no association with the change in mobility. Here, too, the argument of reduced home office opportunities for foreign employees on weekdays may contribute to the explanation, but would have to be empirically examined in greater detail in future analyses. The loss of significance of the rural location with regard to mobility at weekends also seems very plausible, since commuting to work and shopping are no longer an argument.

In the lower part of the table, the estimated coefficient for the spatial lag of the mobility change is also given, which indicates a positive significant correlation between neighboring regions (on weekdays). This result also has a real interpretation, since higher mobility does not halt at county borders and spills over into neighboring regions. The coefficient for the spatial autoregressive error, on the other hand, is insignificant in both models. However, since the LR test does not reject the OLS model, we refrain from interpreting the coefficients (nonlinearly) in terms of direct and indirect effects in the following. See Elhorst (2014) for further details.

5 | How COVID-19 affects spatial development: a discussion.

In the light of the results presented in Section 4, the economic geography and economic policy question arises as to whether the (regional) relationships for the change in mobility also hold beyond COVID-19. Put differently, how does COVID-19 affect spatial development in the long run? It is questionable, however, to what extent these changes will endure the spatial development. No long-term trends can yet be derived from this data analysis on the geography of location, but only individual indicative results which, however, do not represent a causal direct connection to the research question. Another difficulty is that the study is intended to be an ecological study. By definition ecological studies are used to understand the relationship between an epidemic, for instance, and a population impact with specific characteristic such as geography, or socio-economic status.

Remote work and virtual conferencing are the most visible changes due to COVID-19, see also the arguments related to home office discussed in Section 4. In our econometric analysis, the share of graduates and the share of service providers clearly show a significant negative association with changes in mobility. This can be explained by the higher home office rates in service occupations, which often require a higher level of education. It should be pointed out that this observation cannot be applied across all professional groups, so that the impact will also vary from region to region. For instance, before the pandemic, 3 percent of professionals worked exclusively, and 15 percent of professionals worked partially from home, according to a representative survey by Bitkom. During the pandemic, 20 percent (extrapolated around 8.3 million employees) of all professionals worked partially, and 25 percent (extrapolated around 10.5 million employees) of respondents worked completely from home (Bitkom, 2020). There are also tentative indications with regard to future work. For example, larger companies in particular are planning long-term permanent changes with regard to remote office work, depending on the sector of the economy. According to a representative survey of around 1,800 companies in the manufacturing and information industries, long-term changes are to be expected in these sectors (ZEW, 2020). On the opposite, according to Koenig and Dressler (2021), the majority of people conducted in the interviews did not predict mobility behavior changes due to long-term effects of the COVID-19 pandemic. The findings of the article were mainly generated by a representative household survey. However, the households were surveyed in spring 2020, so that the long-term effects could not yet be foreseen. Moreover, the surveys can only provide an initial assessment without defining the long-term effects on the reorganization of the area.

A permanent establishment of decentralized and mobile forms of work will change the requirements for the choice of residential location and suggests to deal with this topic in future research. For example, a shift in housing preferences can be seen in recent surveys and data analyses (ImmoScout24, 2020). An analysis of the demand preferences of real estate seekers based on anonymous search data from 14.8 million users of the portal ImmoScout24-Analysis supports the assumption of increased demand beyond metropolitan cities. For urban surroundings, the portal registered 51 percent more contact inquiries for condominiums and 48 percent more inquiries for houses in June 2020 compared to the previous year. After a decline in inquiries at the beginning of the pandemic, a sharp increase in demand for properties in rural regions was recorded (a 40 percent increase for condominiums and 36 percent for houses compared to the previous year).

But, the significance of these trends is subject to two limitations. First, the increased attractiveness of properties in rural areas did not occur at the expense of urban properties. These also experienced a year-on-year increase in demand in the wake of the lockdown-related catch-up effects in June 2020, albeit at a slightly lower rate. Second, the data do not depict a long-term trend. Beginning in August 2020, the catch-up effects diminished and demand values settled only slightly above year-ago levels (ImmoScout24, 2020). A persistent shift in demand from metropolitan to rural areas could therefore not (yet) be observed.

However, in a dynamic environment ◎ such as the accelerated structural change in society and the economy as a result of the COVID-19 pandemic ◎ the potential of diverging effects by remote office, cultural distance, lack of advantages of urbanization in a pandemic is striking. The development of cities and regions is the result of the respective location factors and spatial structural requirements. The scope for location design at the regional level is limited. In many places, the improvement of these location factors is based on interregional cooperation between the growth centres and surrounding regions in order to exploit the advantages of the division of labor between urban and rural areas. This concept follows the realization that the development of a region does not proceed in isolation from that of its neighboring regions. There are intensive interrelationships in labor, service and real estate markets and pronounced development relationships between neighboring regions. In this respect, it remains critical whether the diverging effects resulting from the COVID-19 pandemic are stronger than the concentration advantages of economic, social, and cultural interaction.

6 | Conclusion

In the wake of the COVID-19 pandemic, mobility in general decreased by about 13% in January 2021 compared to the previous year. Given that direct government restrictions on mobility have existed almost universally this month, the question arises: what socioeconomic regional characteristics are influencing the degree of mobility change in the wake of COVID-19? And from an economic perspective, we ask the compelling follow-up question: what can be learned from the COVID-19 mobility shock observed now for future requirements for changing mobility and regional planning?

First, the results show that regions with a high share of academics among the workforce were more able to significantly reduce weekday mobility. This supports the theses already discussed in the literature and daily press about the urban exodus to the rural home office. But what will happen after COVID-19? Will there be a two-class society of urban outmigration for highly vs. low-skilled employees? Some first studies from the UK and the US are starting to discuss how COVID-19 possibly affects the economic geography. It might seem that the pandemic crisis is going to stabilize regional economic divergence and that it has come to an end of booming cities and left-behind places (Hendrickson and Muro, 2020; Farmer and Zanetii, 2021). Moreover, will previously disadvantaged rural regions seize the opportunity and improve the living and working environment for academics? The impact of broadband coverage (i.e., home office opportunities for high-skilled professions) underscored this in our results. Farmer and Zanetii (2021) assume as well that remote work will be performance-linked on broadband connections and localized digital infrastructure. With the discussion on rising real estate prices in metropolitan areas, we have taken up this trend from a different angle. Whether and when rising prices will act as a corrective to the urban flight trend remains an interesting research question in the medium term. Moreover, empirical studies on the impact of exogenous shocks on mobility behavior and public transportation suggest that the COVID-19 crisis could change social behavior permanently (Gutiérrez et al. 2020; Wang, 2014). More empirical research analysis will be needed in the future to give answers to these questions.

The fact that not all regions with their heterogeneous socioeconomic population profiles succeed in reducing population mobility to the same extent raises spatial policy issues. Regions with high unemployment in the previous year seem to be at a disadvantage in this respect. The flexibility required to find a new job and possibly to accept jobs with a high mobility requirement (delivery services) for lack of a better job options could be two of the multiple causes. So, is there still an "export" of labor out of the region when unemployment is high? How can this be addressed in the future, especially for low-skilled jobs? How can home office opportunities increasingly be tapped for non-academic occupations? In general, our results show that a rural location further reduces the ability to restrict mobility. Not only in the context of demographic change, but also in terms of education, health, and location policy, these are interesting questions that will only be sharpened by an evaluation of the experience of the first COVID-19 year.

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