Zoomshock: The geography and local labour market consequences of working from home.*

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This version: 06 January 2021
Originally: 17 December 2020

Abstract

The Covid-19 health crisis has led to a substantial increase in work done from home, which shifts economic activity across geographic space. We refer to this shift as a *Zoomshock*. The Zoomshock has implications for locally consumed services; much of the clientèle of restaurants, coffee bars, pubs, hair stylists, health clubs, and the like located near workplaces is transferred to establishments located near where people live. In this paper we measure the Zoomshock at a very granular level for UK neighbourhoods. We establish three important empirical facts. First, the Zoomshock is large; many workers can work-from-home and live in a different neighbourhood than they work. Second, the Zoomshock is very heterogeneous; economic activity is decreasing in productive city centres and increasing residential suburbs. Third, the Zoomshock moves workers away from neighbourhoods with a large supply of locally consumed services to neighbourhoods where the supply of these services is relatively scarce. We discuss the implications for aggregate employment and local economic recovery following the Covid-19 health crisis.

Keywords: Covid-19, lockdown, work-from-home, local labour markets
JEL Classifications: R12, J01, H12

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*We gratefully acknowledge financial support from UK Research and Innovation and the Economic and Social Research Council (ESRC grant number ES/V004913/1). Supplemental material may be found at `https://perma.cc/P6RR-NMW4`

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1 Introduction

A defining feature of modern life is the office. And the concentration of offices in city centres and business parks has meant commuting is a fact of life for many workers. As the lot of a commuter is to spend much of their time away from home, their consumption reflects that. Workers buy sandwiches for lunch, coffee during breaks, and after-work drinks. They also visit retail shops near their offices, have their hair cut between meetings, visit gyms before work, they use taxis, have their car serviced while they are in the office, and so on. These are all examples of locally consumed services (LCS): these are services defined by necessarily being supplied and demanded in a given place.

The Covid-19 pandemic has led to an unprecedented shift in the fraction of work that is done from home versus the office. This geographic shift in productive activities, which we refer to as the *Zoomshock*, moves work and workers from their offices in high density urban areas to comparatively low density residential neighbourhoods. This has had important consequences for providers of LCS. Establishments previously patronised by commuters are suffering, while neighbourhood establishments have seen a surge in demand from homeworkers.

This paper has two objectives. First, we propose an empirical measure of the Zoomshock. This metric reflects the change in of work activities (measured as the number of employees or total income) for a given neighbourhood. It weights the difference between workers who work and live in a given neighbourhoods by their ability to work-from-home. We use this method to estimate Zoomshocks for each neighbourhood in England, Scotland and Wales. A clear

pattern emerges: the Covid-19 Zoomshock has moved productive activity away from formerly highly output city centres into residential areas.

Second, we examine the consequences of the Zoomshock for LCS in the affected neighbourhoods and employment in the larger industry. In the short to medium-run the Zoomshock creates a geographic supply-demand mismatch; there are many LCS businesses in city centres but relatively few in the residential suburbs. Even when we allow for perfect mobility of labour, the fact that capital is slow to move, and the lack of density in the suburbs, means that LCS employment will fall below its pre-Covid-19 level.

We believe that the concept of Zoomshock will prove useful for deigning policy that seeks to minimise the economic damage caused by the Covid-19 pandemic, and to use scarce resources devoted to economic recovery as efficiently as possible. Although preliminary, several implications are clear from our analysis. First, at the local level there is very significant geographic heterogeneity within urban areas in how working from home will impact LCS businesses. Any recovery assistance policy should reflect this heterogeneity and focus resources on firms and workers in neighbourhoods who have experienced a negative Zoomshock. Second, the aggregate consequences across neighbourhoods of the Zoomshock will be in larger in some areas. Local authorities where the skewness of the neighbourhood-level Zoomshock distribution is greater are likely to suffer a greater employment loss in the LCS industry. Finally, it is critical that we understand better the long-run consequences of the Zoomshock. The efficient policy prescription will depend crucially on how many former commuters continue to work-from-home once the Covid-19 pandemic subsides. If the switch to working-from-home is permanent for at least some of the work-

ers, for at least some of the time, it may portend long-lasting changes in the productive structure of localised areas: 50% of the commuters to an area switch to working-from-home for two days per week is a 20% loss in potential demand for the area LCS. In the long term, establishments providing LCS may drift from the high streets to the suburbs.

It should be stressed that we do not attempt to fully capture the effect of the Covid-19 pandemic on the LCS industry. This industry has been hit particularity hard by social distancing measures, and will undoubtedly be negatively impacted if the broader economy struggles to recover following the pandemic. Here we abstract from these effects of the pandemic, both for LCS and the broader labour market, and focus on how homeworking specifically will impact these businesses. These consequences, and the implications for recovery policy, are have not yet been studied but the potential implications of working-from-home for the recovery of employment and output in the wake of the Covid-19 pandemic are, as we will see, of first-order importance.

This paper complements empirical studies that look at the regional geography of economic risks arising from the Covid-19 pandemic (Davenport et al., 2020). We emphasise the importance of working with relatively small areas: in theory, and as we will empirically demonstrate, a small local area may be severely affected by the Zoomshock while neighbouring areas potentially benefit from the shock. Zoomshocks are also very complex: they depend on (i) commuting patterns: these are highly asymmetric, most commuters travel from "residential areas" in cities, the suburbs, or the countryside to work in city-centres; (ii) the ability of commuters to work remotely: office workers with little contact with customers can work-from-home easily, vets and events managers

with greater difficulty if at all; (iii) commuters' demand for LCS: this in turn depends on both the commuters' income and the fraction they spend on LCS— expensive wine bars are LCS, but home delivery of cases of fine wine is not, and how much of the LCS are consumed at work— the services supplied by gardeners and nannies are by their nature not consumed at the work location. (iv) and finally on the ability of supply to adjust to increased demand: a community with many home-working residents may find that some continue to demand similar LCS as when they commuted, e.g. they may still prefer to buy their lunch, rather than prepering it themselves. But existing businesses might be unable to increase their supply to satisfy this demand.

This paper contributes to an emerging evidence base on the costs, in labour market terms, of stay at home orders. Baek et al. (Forthcoming), provides evidence that stay at home account for less than a quarter of total Covid related job losses in the US. But this impact has been uneven. Crossley et al. (2021), using panel data for the UK, find that the impacts of the pandemic have been most pronounced for those on the lowest incomes, and those from minority ethnic groups. Mongey and Weinberg (2020) find similar results for the US. Angelucci et al. (2020) also find that health losses are disproportionately concentrated on these groups. Barrero et al. (2020) suggest that 42% of jobs lost due to Covid in the US will be permanent.

It also contributes to a second strand of the post-Covid literature whose focus is on which, and how many, jobs can be done from home. Dingel and Neiman (2020) provided early U.S. and international evidence. Alipour et al. (2020) provide similar evidence for Germany. In this paper we add to this literature by proposing a classification for the UK, and mapping occupation and

wage heterogeity in ability to work-from-home to geographic heterogeneity. Gottlieb et al. (2020) study what share of jobs are tele-workable across countries, documenting that fewer jobs are tele-workable in lower income countries, in part due to the higher share and nature of self-employment in those countries.

Others have documented the impact on consumption patterns (Baker et al., 2020; Barrero et al., 2020; Chronopoulos et al., 2020). To our knowledge there has been little attention to the spatial aspects of these changes.

This is one of the few papers to consider the spatial aspects of working-from-home. In contemporaneous work Delventhal and Parkhomenko (2020) provide a quantitative model for Los Angeles to study how in the long-run teleworking may affect the spatial distribution of jobs and residents. In another contemporaneous contribution Delventhal et al. (2020) introduce a quantitative spatial equilibrium model in which workers are heterogeneous in the amount of time they work "on site". Their model predicts a non-monotonic impact of teleworking—increasing activity in the most productive cities while also in the lowest density areas.

This paper proceeds as follows. In Section 2, we specify how we measure the Zoomshock, characterising it by geographic shifts in workers and geographic shifts in GDP. In Section 3 we discuss the data which we use in our primary analysis: this comes from the UK Annual Survey of Hours and Earnings. In Section 4 we use these measures to examine the Zoomshock across Britain, and how working-from-home has changed the geography of productive activities. In Section 5 we discuss, and provide some theoretical basis for, the impact that working from home has on the LCS industry at highly localised levels and on

aggregate LCS employment. We conclude with some discussion of the outstanding information needed and implications for short and longer-term policy.

2 The Zoomshock

We use the term *Zoomshock* to describe the geographic change in economic activity due to the shift towards working-from-home during the Covid-19 pandemic. Here we present metrics that can be calculated using existing data and capture the differences in the sign and magnitude of the Zoomshock in different neighbourhoods. We consider two different ways of thinking about a change in economic activity. The first is by looking at the geographic change in the number of workers (which will be the focus of our empirical analysis). The second is by looking at the geographic change in GDP, measured as the income of these worker.

Consider first the change in the number of workers within a geographically defined zone, z. This change can be estimated by considering three characteristics: 1) the number of workers who work in z; 2) the number of workers who live in z; 3) and whether the jobs performed by these workers can be done at home. In plain English, we wish to calculate a metric, ζ_z, defined as:

$$\zeta_z = \left(\begin{array}{c} \text{weighted count of} \\ \text{workers who are resident} \\ \text{in zone } z \text{ and working} \\ \text{elsewhere: they } \textit{return to } z \end{array} \right) - \left(\begin{array}{c} \text{weighted count of} \\ \text{workers who are working} \\ \text{in zone } z \text{ and resident} \\ \text{elsewhere: they } \textit{leave } z \end{array} \right), \quad (1)$$

where the weighting of the count is given by the measure of the ability to per-

form their work at home. This is the difference between the number of workers who are able to leave zone z to work from their home located in zone $z' \neq z$, and the number of individuals who are resident in zone z and are able to work from home instead of having to go in person to zone $z'' \neq z$.

Formally, (1) can be calculated for each zone z as follows:

$$\zeta_z = \sum_i \mathbf{HD}_i' \left(\mathbb{1}[residence_i = z] - \mathbb{1}[work_i = z] \right), \tag{2}$$

where $\mathbb{1}[\cdot] \in \{0, 1\}$ is an indicator function. $\mathbb{1}[residence_i = z]$ equals 1 if individual i lives in zone z, and 0 otherwise; $\mathbb{1}[work_i = z]$ equals 1 if individual i works in zone z, and 0 otherwise. $\mathbf{H}$ and $\mathbf{D}_i$ are vectors of occupation-specific work-from-home indices and individual i's occupation, respectively.

The product $\mathbf{HD}_i' \in [0, 1]$ is worker i's work-from-home index, with which we weight each observation. We adapt the home-working classification of Dingel and Neiman (2020) for each of our 380 four-digit UK Standardised Occupation Codes, with minor adjustments required to map US job descriptions to the UK ones. Formally, given a set of occupations $o = 1, \ldots, 380$, $\mathbf{H} = (h_1, h_2, ..., h_{380}) \in [0, 1]^{380}$ is a vector of occupation-specific indices for which an element $h_o \in [0, 1]$ reflects the feasibility of performing the duties required by occupation o in a location other than "work". A delivery driver will generally have a home-working index of $h_o = 0$, an IT software consultant will have an index of $h_o = 1$. Other workers may have an intermediate value, as they can perform some tasks remotely, but some require their physical presence.[1]

[1] As examples of occupations with an index of 0.5, forklift truck drivers, artists, and credit controllers are among them. For security guards, the index is $\frac{1}{3}$, for estate agents $\frac{3}{4}$, and for garage managers and proprietors $\frac{8}{9}$: of the 380 4-digit occupation classified by the ONS, 162 are

$\mathbf{D}_i \in \{0,1\}^{380}$ is a vector of occupation dummies for individual i's main job, that is a vector whose o-th element is 1 if and only if occupation o is individual i's main job.

Our resulting work-from-home index matches well with data reflecting actual working from home (see Appendix B for analysis). We also find that workers who can work from home are paid more (this corresponds to Aum et al. (2020) for the US): controlling for industry, year, age, hours worked, gender, and region of residence, a worker who can work from home is paid over 40% more that one who cannot.

Expression (2) has a number of properties worth pointing out. First, occupations which cannot be done at home, such as those in the LCS industry, will not change the values of ζ_z; occupations for which $h_o = 0$ carry no weight. Second, ζ_z reflects the economic activity of those who commute in or out of zone z; individuals who work and live in the same zone will not affect (2). Third, ζ_z aggregates to higher levels of geographic space. For any geographic area made up of multiple non-overlapping zones, denote this $A = \{z_1, z_2, ..., z_n\}$, we can calculate:

$$\zeta_A = \sum_{z \in A} \sum_i \mathbf{H}\mathbf{D}_i' \left(\mathbb{1}[residence_i = z] - \mathbb{1}[work_i = z] \right). \tag{3}$$

When areas or zones vary considerably in population, as is the case with British local authorities, it will prove convenient, for the sake of comparison, to work also with a per capita Zoomshock: this is obtained by dividing the RHS of Ex-

classified as not suitable for home-working, 124 as partly suitable, and 94 as fully suitable. We provide a descriptive analysis of our resulting work-from-home index in Appendix B.

pression (3) by the number of pre-shock workers in area A.

$$\widehat{\zeta}_A = \frac{\sum_{z \in A} \sum_i \mathbf{HD}'_i \left(\mathbb{1}[residence_i = z] - \mathbb{1}[work_i = z] \right)}{\sum_{z \in A} \sum_i \mathbb{1}[work_i = z]} \times 100. \tag{4}$$

Expression (4) is percentage change in employment activities in area A. $\widehat{\zeta}_A$ can also be calculated for a specific zone, z, as a special case where $A = \{z\}$.

The above expressions look at the change in the number of workers across geography due to a shift to working from home. It is also useful to measure changes in economic activity in terms of the change in the value of output produced in a specific area. To do this we weight equations (3) and (4) by income for each individual i, which we denote by y_i.[2] This gives us

$$\zeta^y_A = \sum_{z \in A} \sum_i \mathbf{HD}'_i y_i \left(\mathbb{1}[residence_i = z] - \mathbb{1}[work_i = z] \right), \tag{5}$$

and

$$\widehat{\zeta}^y_A = \frac{\sum_{z \in A} \sum_i \mathbf{HD}'_i y_i \left(\mathbb{1}[residence_i = z] - \mathbb{1}[work_i = z] \right)}{\sum_{z \in A} \sum_i \mathbb{1}[work_i = z]} \times 100. \tag{6}$$

[2] A substantial recent literature has studied the efficiency of working from home. Bloom et al. (2015) provide evidence from a within-firm RCT that homeworking increases the productivity of call-centre workers by up to 22%. Mas and Pallais (2017) find that the average call-centre worker is willing to pay 8% to work from home. Although, Battiston et al. (Forthcoming) provides evidence that face-to-face communication improves productivity. One reading of these somewhat contradictory results is that the optimum level of working-from-home is some mix of office- and elsewhere-based work. Here, we assume there is no aggregate impact on the productivity of those working-from-home. We also abstract from other consequences of work flexibility (Kelly et al., 2014; Allen et al., 2015; Beckmann et al., 2017; Felstead and Henseke, 2017; Spreitzer et al., 2017; Chan, 2018; Ameriks et al., 2020).

3 Data

We calculate the expressions on the RHS of (2) and (3) using information from the secure version of the *Annual Survey of Hours and Earnings* (ASHE). The ASHE contains a random 1% sample of all employees in England, Wales, and Scotland.[3] In addition to detailed occupation and earnings information, we also observe the precise geographic location of employment and residence for each individual in our data. We construct pre-Covid-19 employment distributions using the 2017, 2018 and 2019 waves of the data. This provides us with observations on approximately $200,000$ workers.

We conduct our analysis at the level of the *Middle Super Output Area* (MSOA) for England and Wales and *Intermediate Zone* for Scotland (for brevity we refer simply to MSOA hereafter). These are areas of roughly the same residential population size (the mean population is around 9000 people).[4] We also consider a second, coarser, geographical partition, the Lower Tier Local Authority (LAD).[5] These are administrative and political units, and vary substantially in size. The largest, Birmingham has a population of over 1 million while the Isles of Scilly a population of just over $2,000$.

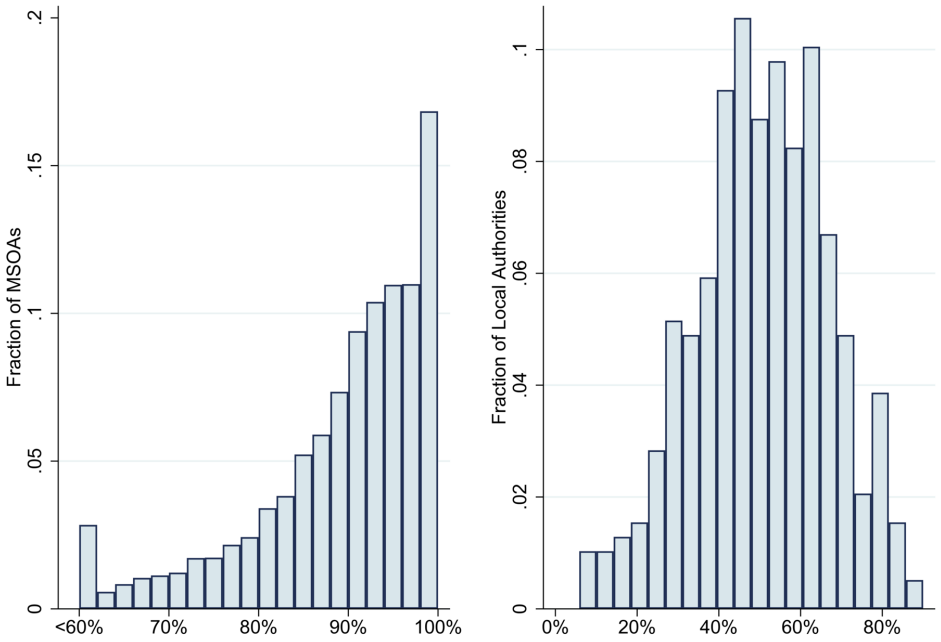
Only 11% of UK workers have the home and the work address in the same MSOA, and there is considerable variation in this proportion across the coun-

[3]Unfortunately, data for the ASHE, required for our analysis, is not available for Northern Ireland.

[4]In principle it would be possible to work with even finer geographies but MSOAs are preferred since they are large enough that they will in general represent a local community with some shops, etc., rather than just a collection of houses. Smaller areas would also ask too much of the data.

[5]Specifically, we analyse the Local Authority Districts in England, the Council Areas in Scotland, and the Principal Areas in Wales.

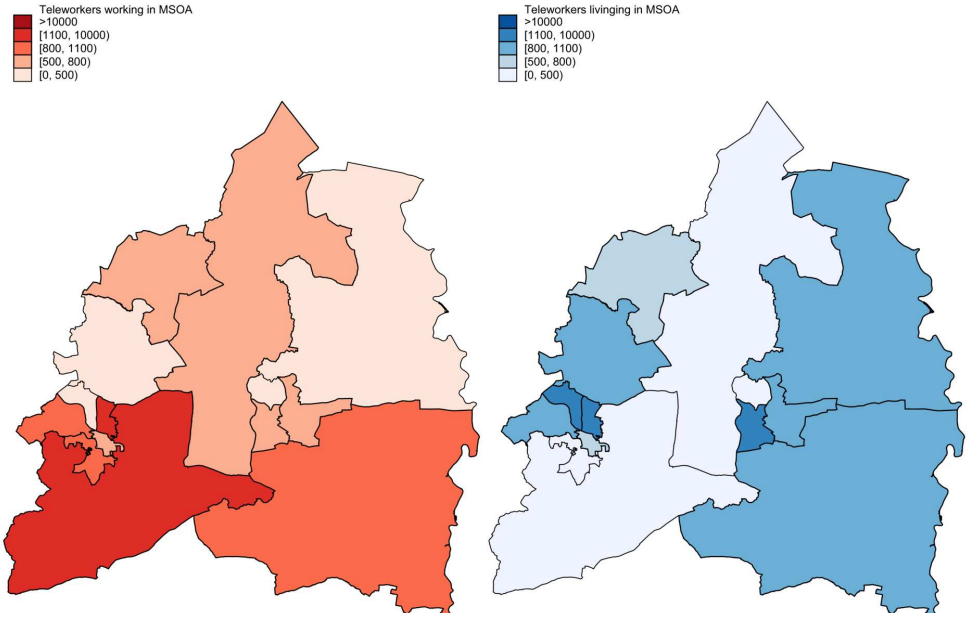
Figure 1:
Commuters by MSOA and Local Authority



Note: The horizontal axis is the percent of residents who work outside of the MSOA (left) and LAD (right) in which they live.
Data source: Authors' calculations based on data from the ONS Annual Survey of Hours and Earnings, 2017, 2018, 2019.

try. In Figure 1 we show the distribution, across all MSOAs, in the proportion of workers who live and work in different MSOAs (i.e. commuters). Clearly, the role of commuting is a significant; in over 97% of MSOAs more than 60% of residents commute for work (Figure 1, left panel). One naturally expects that the proportion of commuters will decrease as the area we look at is larger, but the proportion of commuters remains significant when we look at local authorities: around 50% of workers commute to a different local authority than that in which they live (Figure 1, right panel). Moreover, there is considerable varia-

Figure 2:
Residents and workers who can work-from-home, Bassetlaw



Note: These maps show, for each MSOA, the number of workers who are resident in each MSOA and can work-from-home (left map), and the number of workers whose place of work is in the MSOA and can work-from-home (right map).
Data source: Authors' calculation based on data from the ONS Annual Survey of Hours and Earnings, 2017, 2018, 2019.

tion: some LADs have over three quarters of their residents working elsewhere, in others LADs fewer than one in five do so. Thus, commuting even between large areas is common and varies in extent.

4 Geography of the Zoomshock

As an illustration, we begin our analysis—like so many others—by considering Bassetlaw. This is a relatively small LAD, 150 miles north of London. There are 14 MSOAs in Bassetlaw; for each MSOA, we compute the number of em-

ployed residents who can work from home: this is first term in Equation (1), and is depicted on the left map of Figure 2. We next compute the corresponding number of workers whose place of work is in an MSOA in Bassetlaw, but who can work-from-home in a different MSOA (possibly also in the Bassetlaw local authority): this is the second term in (2), and is depicted on the right map of Figure 2. The MSOA known as Bassetlaw 014 (the large dark red region on the left map of Figure 2) has approximately 1465 workers who live in the MSOA, but 5661 workers who work in the MSOA. Of the former, we compute that 485 workers can work-from-home, approximately one third. Of the latter, 1,828 can work-from-home, again just about a third. Therefore, if all workers who can work from home do so, we expect Bassetlaw 014 to see a net decrease in employment of approximately $1,828 - 485 = 1,343$ workers.

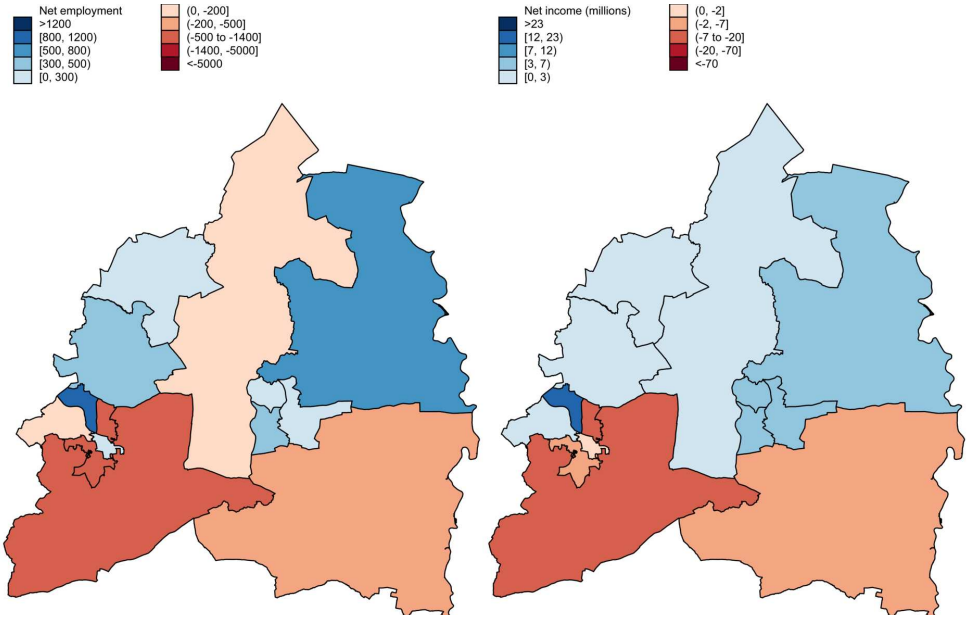
The maps in Figure 3 show the corresponding Zoomshock for each of the MSOAs in the Bassetlaw local authority. The map to the left of this figure illustrates the net inflow of homeworking workers (Equation (2)), and reflects the difference between the left and right maps of Figure 2. Red (blue) areas correspond to MSOAs in which home working results in less (more) economic activity, that is MSOA z for which (2) is negative (positive). The depth of the shades of red and blue corresponds to strength of the flow, a deeper shade indicates a larger flow. Boundary between colour bins are set, for positive and negative values separately, at Zoomshock values approximately at the 20th, 40th, 60th, 80th and 95th MSOA percentiles for Britain.

The right hand side map of Figure 3 reports the same exercise for Equation (5), so the Zoomshock reflects changes in the value of economic activity across MSOAs. This is different way of looking at the geographic shift in economic ac-

tivity due to home-working, and roughly corresponds to the potential change in the annual GDP for a area z. Notice that quintile assignments of the two Bassetlaw maps in Figure 3 are roughly in agreement with one another, but there are differences, for example, there are two changes in the sign of the flow: one MSOA for which the change in the flow of workers is negative (positive), while the corresponding GDP change is positive (negative). An area with a negative net-flow of workers (a red shade on the LHS map) and a positive GDP net-flow (a blue shade on the RHS map) is one where the residents are relatively highly paid workers, and although those who stop commuting to work from home are fewer, they are sufficiently better paid on average to more than offset the incomes of the larger number of workers who no longer need come into the area to work. In the maps and analysis that follow, for brevity, we focus primarily on the Zoomshock in terms of workers, and leave the important analysis of income flows for future research.

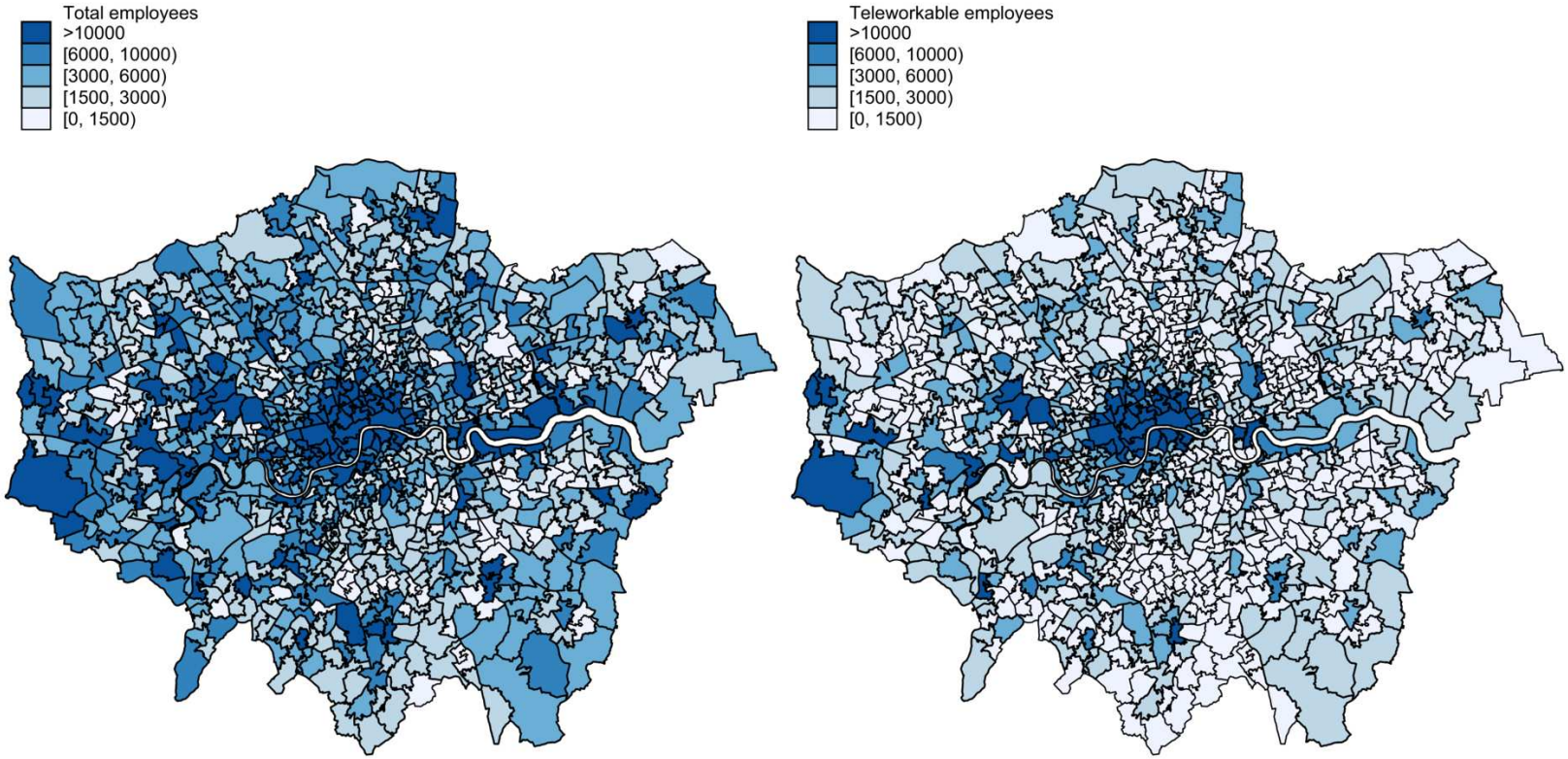
The primary drivers of variation in the Zoomshock are the distribution of where people live relative to where they work, and the geographic clustering of work which is potentially suitable for home-working. We illustrate the second in Figure 4 for the Greater London Authority. The left-hand-side map shows the geographic distribution of all employment; the right hand side map shows employment weighted by the home-working index. The comparison between the two panels makes it clear that jobs suitable for home-working are disproportionately concentrated in the centre of London.

Figure 3:
Zoomshock by workers and GDP, Bassetlaw



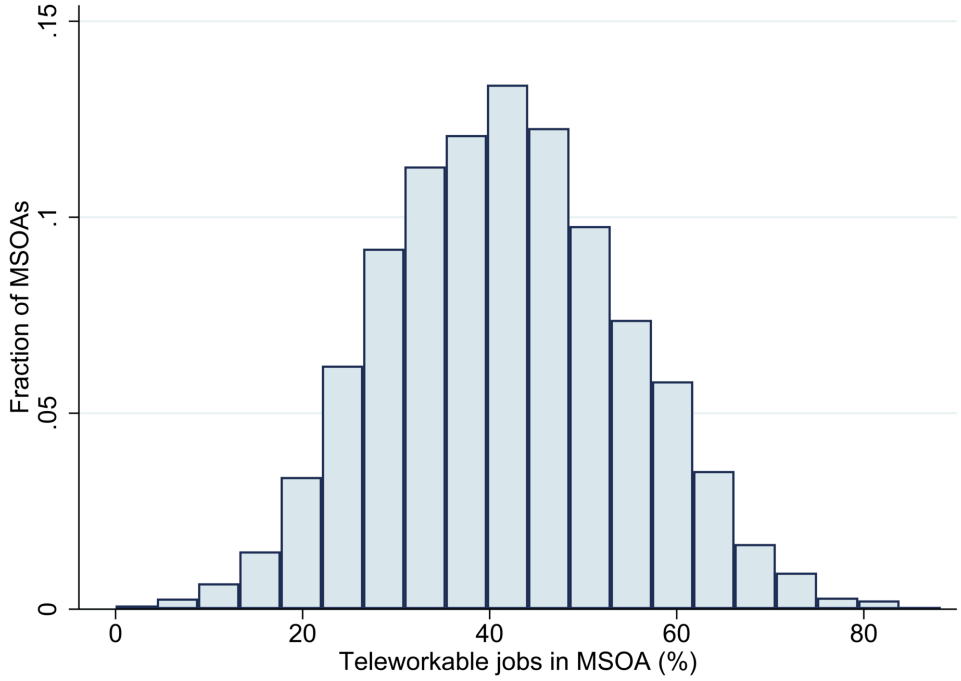
Note: These maps show quantiles of expressions (2) and (5) by MSOA. Quantile boundaries are calculated separately for positive and negative shocks to represent the 25th, 50th, 75th, and 95th percentiles for Great Britain.
Data source: Authors' calculation based on data from the ONS *Annual Survey of Hours and Earnings*, 2017, 2018, 2019.

Figure 4:
Employees and employment suitable for working-from-home, Greater London Authority



Note: The maps show the netflow of workers from each area (see the note to Figure 3 for details). On the LHS, each area is an MSOA, on the RHS a London Borough.
Data source: ONS Business Structure Database , 2018. Proportion of homework by MSOA based on authors calculations using information from the ONS Annual Survey of Hours and Earnings, 2017, 2018, 2019.

Figure 5:
Geographical differences in suitably of jobs for working-from-home.



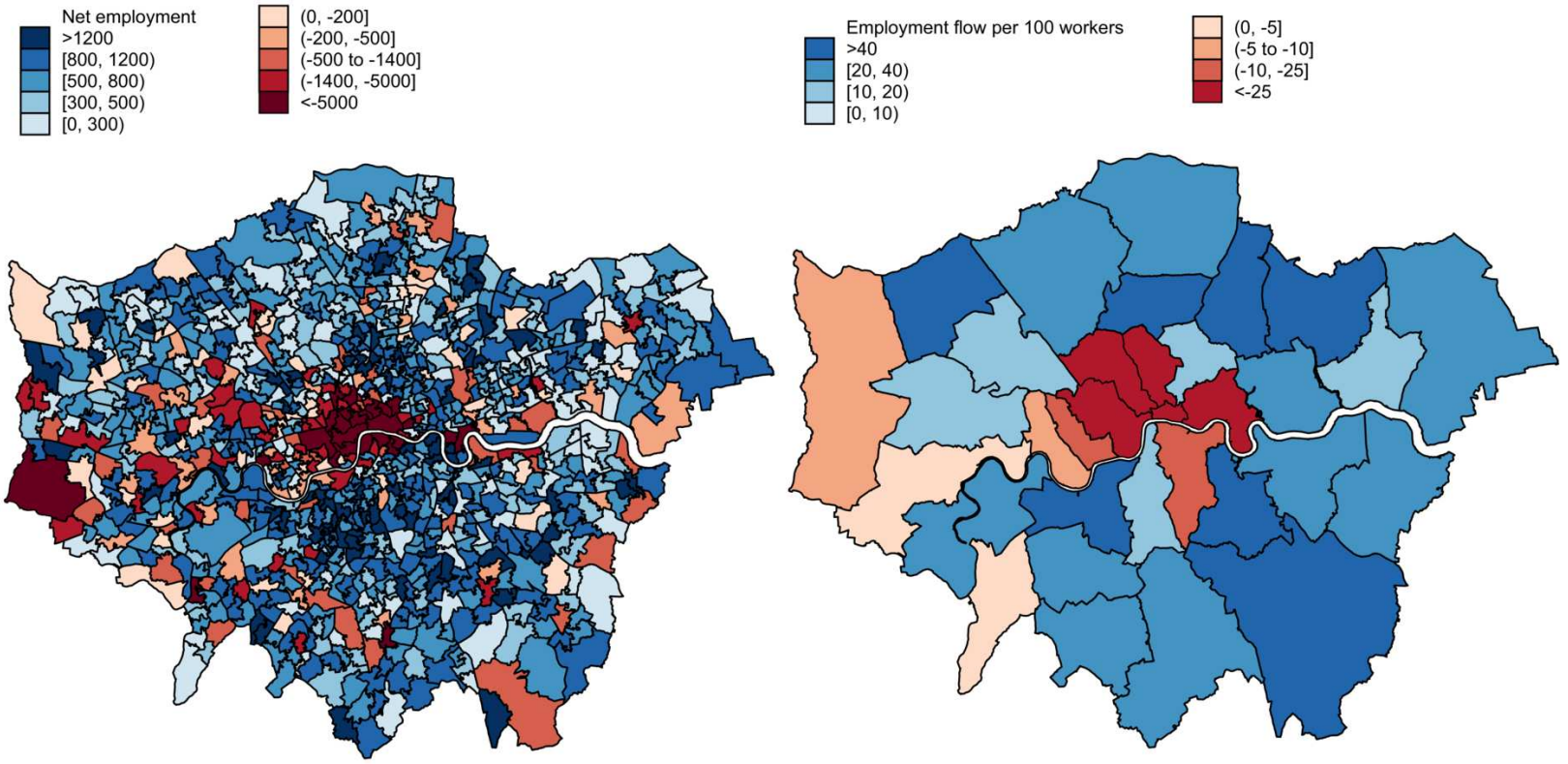
Note: The horizontal axis reports the estimated percent of total employment, within an MSOA, that is suitable for working-from-home.
Data source: Authors' calculation based on data from the ONS Annual Survey of Hours and Earnings, 2017, 2018, 2019.

Both maps show that neighbouring areas may have widely varying proportion of workers with the ability to work remotely. This is summarised more generally for the whole of the UK in Figure 5. In some MSOAs more than 60% of residents can work-from-home, while in many others only fewer than 30% of residents can work-from-home. The same is true at local authority level. As we shall see, it is this heterogeneity that gives the Zoomshock its bite. In Figure (6) we illustrate the Zoomshock for the Greater London Authority, at the level of the MSOA (ζ_z from Equation (2)) and aggregated to the local author-

ity ($\widehat{\zeta}_A$ from Equation (4)). Both maps confirm the familiar pattern of workers living on the periphery of the metropolis and working in the inner city. If MSOA Zoomshocks are generated within local authorities, we would expect to see $\widehat{\zeta}_A \approx 0$. These maps demonstrate that this is not the case, workers in central London are commuting from beyond the local authority.[6]

[6]The deep-red colouring of some areas on the western border of London also reflects this.

Figure 6:
Zoomshock, Greater London Authority



Note: These maps show quantiles of expressions (2) and (3) by MSOA (left) and local authority (right). Quantile boundaries are calculated separately for positive and negative shocks to represent the 25th, 50th, 75th, and 95th percentiles for Great Britain in the left-hand side map and the 25th, 50th, 75th, and 95th percentiles for Great Britain in the right-hand side map.
Data source: Authors' calculation based on data from the ONS *Annual Survey of Hours and Earnings*, 2017, 2018, 2019.

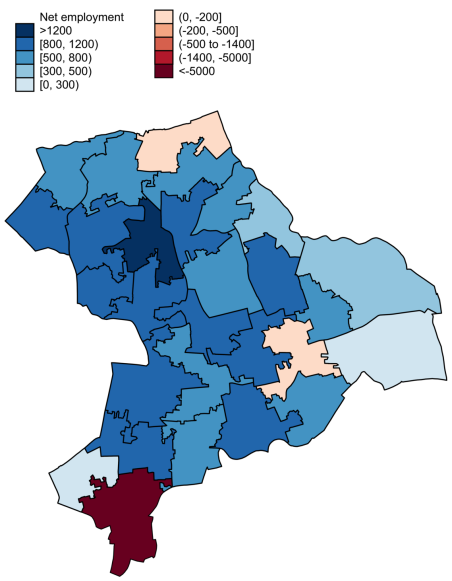
These maps illustrate the importance of a very granular view: there are sharp, often extreme, differences among neighbouring areas. These differences are lost when a coarse partition is chosen. The map on the LHS in Figure 6 shows a more fragmented distribution, indicating that there are substantial variations within boroughs. This can be seen in more detail in the close up of the London boroughs of Hackney and Kensington and Chelsea that we show in Figures 7a and 7b. Even though Hackney as a whole is an area of net inflow (more people are returning than are leaving), there are pockets with a large net outflow (those in pink and deep red in the map). The picture is similar, if with the reverse signs, for Kensington and Chelsea; patterns of deep red neighbour areas of blue.

This is not just a London (or Bassetlaw) phenomenon. We also report the Zoomshocks for (the nine local authorities of) Greater Birmingham and Solihull, for (the ten local authorities in) Greater Manchester, and for (the four local authorities in) the Sheffield City Region: these are Figures 8-10. Again these highlight the highly asymmetric pattern of commuting from where people live to where people work: some areas predominantly serve as residences, others are mainly places for work. In the Appendix to this paper , we provide Zoomshock maps for a wide variety of LADs and counties across England, Wales and Scotland.

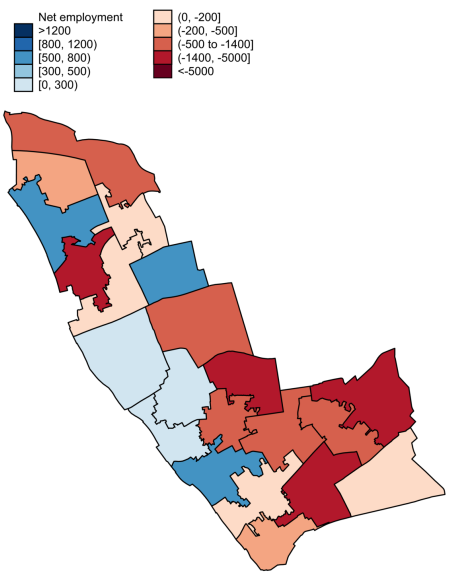
In Figure 11, we map $\widehat{\zeta}_A$ by local authorities for the the whole of Great Britain (omitting the Shetland and Orkney Islands). A couple of interesting features are worth point out. First, the majority of the areas on the map are blue, suggesting a positive Zoomshock. This is unsurprising, as pre-home-working economic activity tends to concentrate in few, relatively dense, geographic areas. Second,

Figure 7:
Zoomshock, Hackney and Kensington & Chelsea

(a) Hackney



(b) Kensington and Chelsea

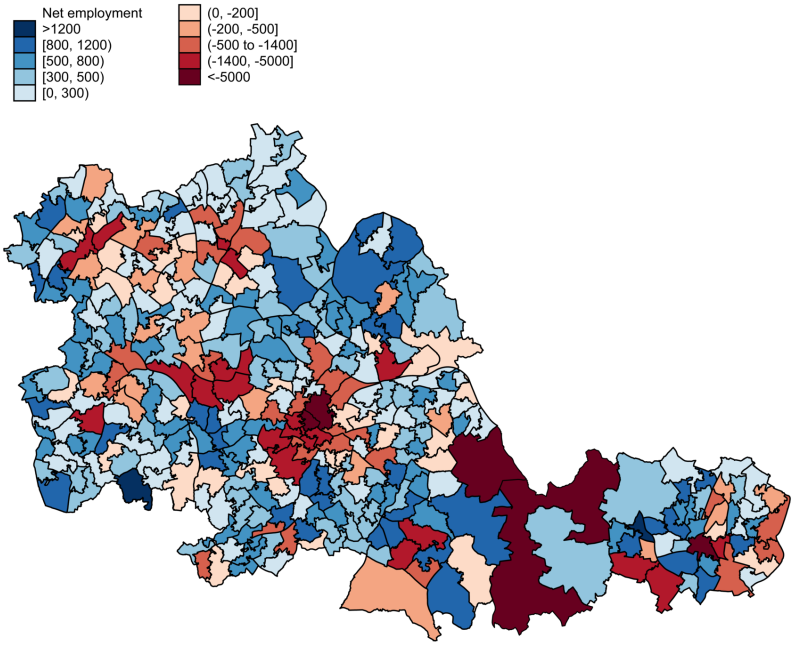


Note: This map shows quantiles of Expression (2) by local authority. Quantiles boundaries represent the 25th, 50th, 75th, and 95th percentiles for Great Britain, calculated separately for positive and negative shocks.
Data source: Authors' calculation based on data from the ONS *Annual Survey of Hours and Earnings*, 2017, 2018, 2019.

larger (in terms of area) local authorities appear to be more likely to have positive Zoomshocks, while small local authorities are more likely to have negative Zoomshocks. This reflects an important feature of the Zoomshock, economic activity is flowing to less-densely populated parts of Britain. These features both suggest that working-from-home is leading to economic activity being significantly less geographically concentrated.

In Table 1 we list the ten local authorities with the largest negative and positive Zoomshocks. The top of the list of negative shocks is perhaps somewhat

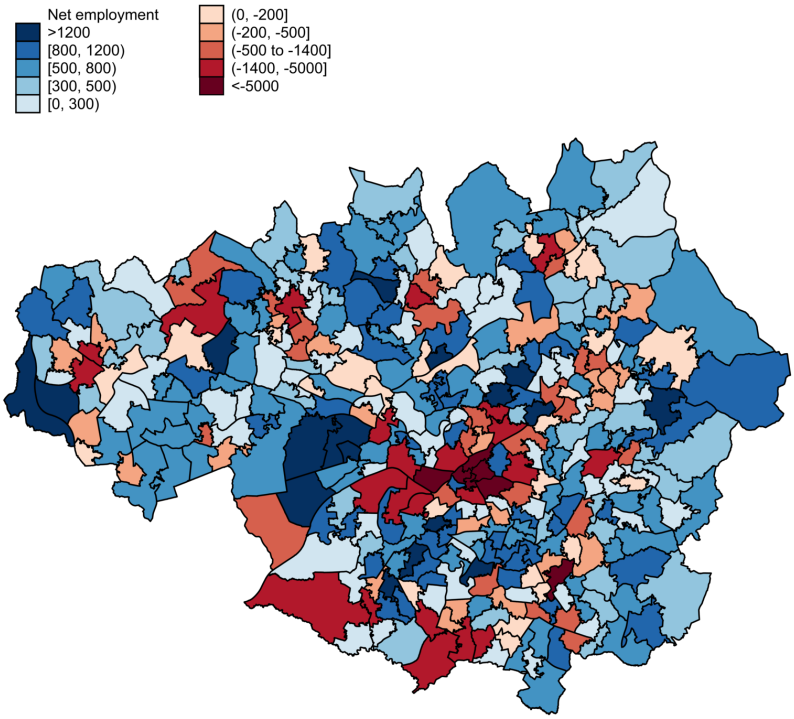
Figure 8:
Zoomshock, Greater Birmingham and Solihul



Note: This map shows quantiles of Expression (2) by local authority. Quantiles boundaries represent the 25th, 50th, 75th, and 95th percentiles for Great Britain, calculated separately for positive and negative shocks.
Data source: Authors' calculation based on data from the ONS *Annual Survey of Hours and Earnings*, 2017, 2018, 2019.

predictable, as six of the top ten are in Central London. However, other local authorities, such as Nottingham and Newcastle are perhaps a little more surprising. The magnitude of the Zoomshocks are substantial—three-quarters of workers in the City of London and half of those in Westminster can work-from-home. The boroughs with the largest positive shocks are again predominantly in London, although now they reflect the primarily residential authorities of outer London.

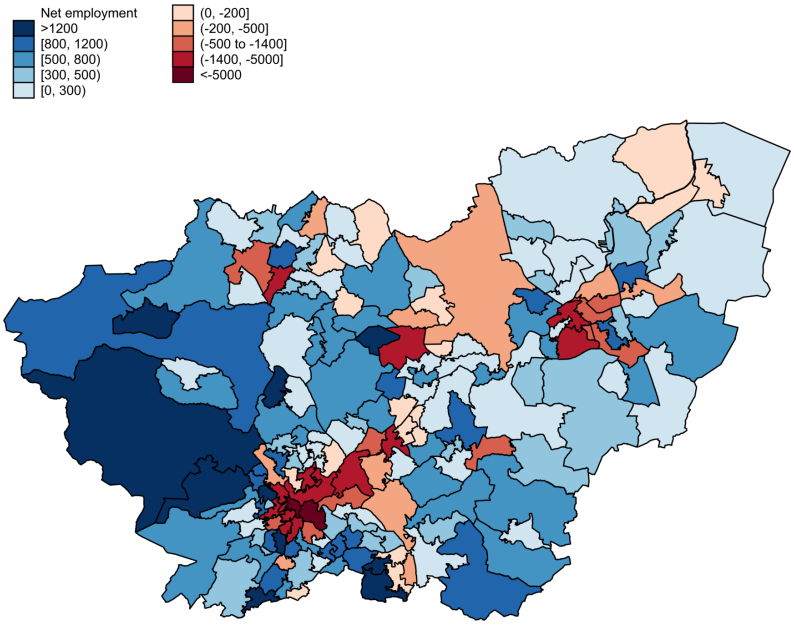
Figure 9:
Zoomshock, Greater Manchester



Note: This map shows quantiles of Expression (2) by local authority. Quantiles boundaries represent the 25th, 50th, 75th, and 95th percentiles for Great Britain, calculated separately for positive and negative shocks.
Data source: Authors' calculation based on data from the ONS *Annual Survey of Hours and Earnings*, 2017, 2018, 2019.

Another interesting feature of the data is the differences in the GDP shock. East Dunbartonshire has a larger increase in the number of workers than East Renfrewshire, but the implied increase in GDP is only around one third of the size. This emphasises that not only is there important heterogeneity in the numbers of workers in an MSOA able to work-from-home but there is also substantial variation in how much they earn and likely spend. This is important as it suggests that there may be a reversal of fortune, the most prosperous areas, like

Figure 10:
Zoomshock, Sheffield City Region



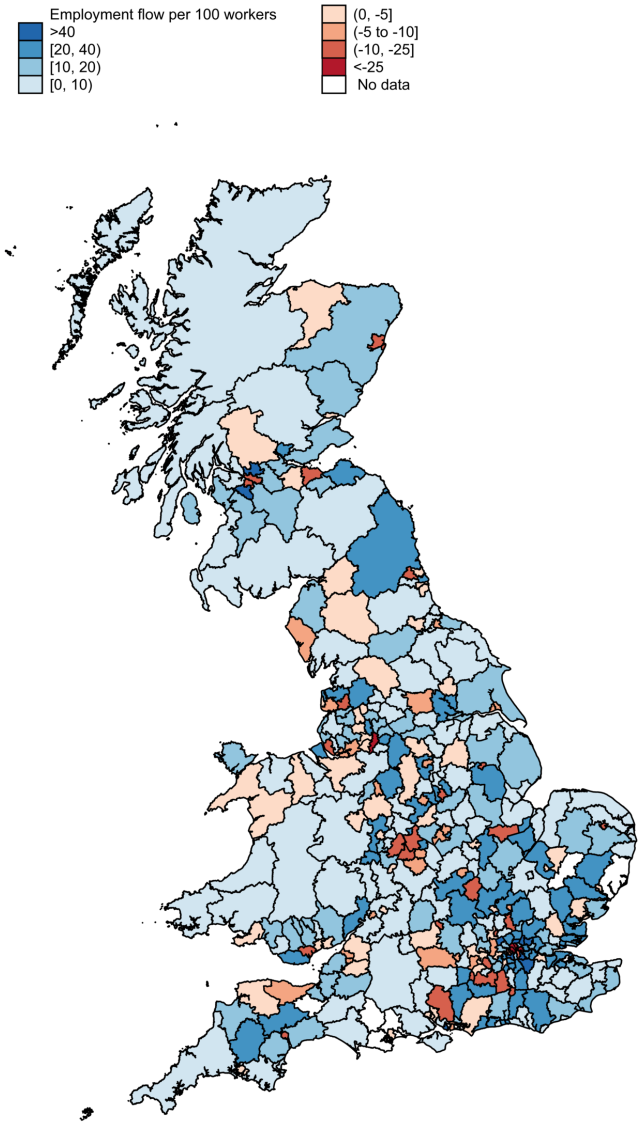
Note: This map shows quantiles of Expression (2) by local authority. Quantiles boundaries represent the 25th, 50th, 75th, and 95th percentiles for Great Britain, calculated separately for positive and negative shocks.
Data source: Authors' calculation based on data from the ONS *Annual Survey of Hours and Earnings*, 2017, 2018, 2019.

the City of London, previously characterised by large numbers of highly paid commuters are the places most affected. One thing this highlights is that the places that might be most affected are those where, even if fewer in number, commuters account for a large share of GDP.

5 The Zoomshock and LCS workers

The analysis so far illustrates the considerable variability of the Zoomshock across MSOAs. In this section we analyse the implications of this variation for

Figure 11:
Zoomshock, Great Britain local authorities



Note: The maps show the netflow of workers from each MSOA (Equation (2), see the note to Figure 3 for details).
Data source: Authors' calculation based on data from the ONS Annual Survey of Hours and Earnings, 2017, 2018, 2019.

Table 1:
Largest negative and positive Zoomshock by local authority

Local authority	$\widehat{\zeta}_A$ (workers)	$\widehat{\zeta}^y_A$ (GDP†)
Negative		
City of London	-75.6	-2,592,970
Westminster	-49.9	-1,218,470
Camden	-43.1	-648,598
Tower Hamlets	-33.9	-1,234,626
Islington	-30.4	-587,529
Manchester	-25.1	-410,680
Southwark	-24.4	-470,561
Cambridge	-23.3	-371,215
Newcastle upon Tyne	-22.2	-267,416
Nottingham	-21.5	-277,061
Positive		
Redbridge	69.1	1,341,043
Lewisham	64.6	1,294,023
Harrow	61.9	1,200,129
Waltham Forest	60.3	1,156,035
East Dunbartonshire	57.4	384,360
East Renfrewshire	52.8	1,050,853
Haringey	46.8	936,223
Gosport	42.3	613,793
Wandsworth	41.3	1,474,134
Bromley	40.7	1,087,333

Calculations correspond to expressions (4) and (6).
†GDP shown as pounds per annum.
Data source: Authors' calculation based on data from the ONS Annual Survey of Hours and Earnings, 2017, 2018, 2019.

the LCS sector. The key point is that while the Zoomshock is itself additive across zones—as can be seen from expressions (3) and (5)—the consequences of the Zoomshock for area employment in the LCS industry are almost certainly

not additive. This is because the presence of frictions, such as imperfect labour mobility and capacity constraints, means that a movement in LCS demand from one zone to another will not, in the short- and medium-run, be perfectly mirrored by a movement in LCS supply.[7] As a result, we expect to see a decrease in aggregate LCS employment, with wages increasing in positive Zoomshock neighbourhoods.

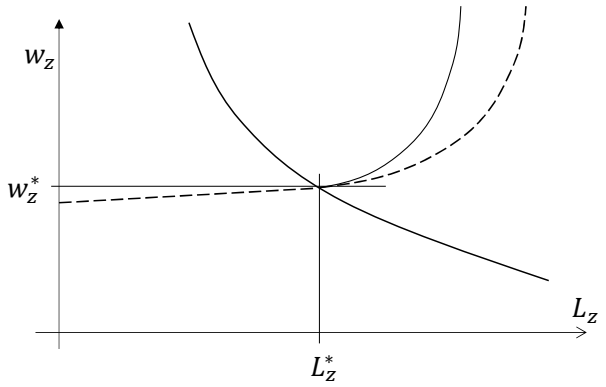
A complete formal analysis is beyond the scope of this paper, instead in this section we present an intuitive graphical analysis of the short-medium run effects of the Zoomshock on the distribution of LCS employment and economic activity. We show that the aggregate impact on LCS employment in a LAD depends crucially on the shape of the distribution, and specifically the skewness of positive MSOA Zoomshocks.

To this end, Figure 12 depicts the demand and the supply for LCS workers in zone z in the pre-Zoomshock equilibrium, given by (L_z^*, w_z^*), where L_z is the number of LCS workers and w_z is the wage. To simplify the analysis we make the assumption that all the demand for LCS workers comes from non-LCS workers. This strong assumption is only to aid calculations and carve in sharper relief the distinction between the two groups of workers.[8] The pre-Zoomshock intersection of demand and supply in zone z reflects a long-run spatial equilibrium. This is reflected by the shape of the supply function, depicted as the dashed curve where LCS workers are in their preferred job and residence. From

[7] To focus on the effect of the geographic change in *where* work is done, we assume that LCS demand from workers is independent of whether they work from home or the office. This is likely an overly-optimistic assumption. For example, having access to a one's own kitchen may decrease demand for restaurant food when one works at home relative to the office.

[8] Thus, a barber (who is a LCS worker) may have lunch in a local restaurant, and if he stops working, due to the fact that many of his customers are teleworking, the restaurant will lose the barber's custom as well, amplifying the effect of the non-LCS worker remote working.

Figure 12:
Equilibrium in the LCS labour market in zone z.



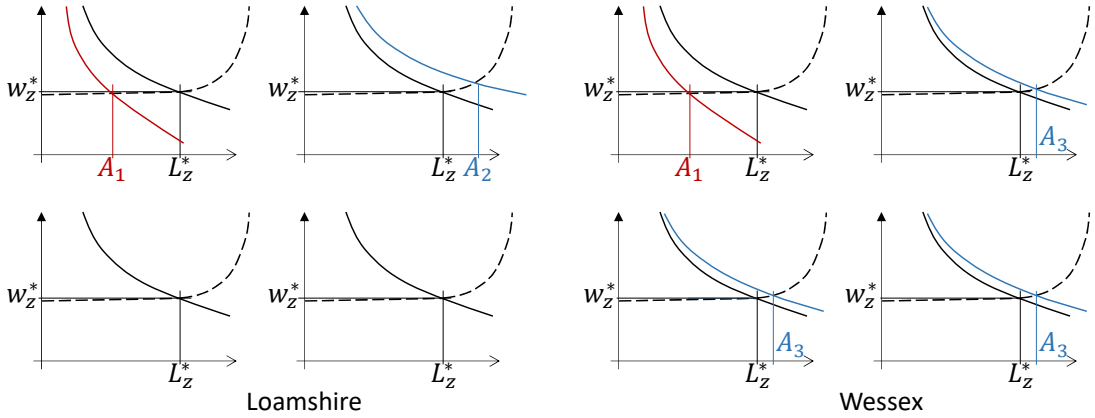
Note: This figure illustrates the market for LCS workers in a zone z. The downward sloping curve shows demand for workers (L_z) at each wage (w_z). The dashed and solid upward sloping curves depict two possible supply curves for z.

this equilibrium in order to attract new LCS workers, businesses in zone z will need to pay progressively higher salaries. Initially, the increase might only need to be small to attract workers close to indifferent between their current zone and zone z, but then larger increases will be needed to persuade others to move to or to commute to zone z. The shape of the supply function, in particular the "steepness" of the curve beyond the initial equilibrium, depends on the characteristics of zone z, such as the geographical proximity and type of neighbouring zones. As an example, in a sparsely populated zone an LCS business may find that larger wage increases are necessary to attract additional staff, who would have to travel substantial distances to work.[9]

The aggregate effect of the Zoomshock on LCS employment for a LAD depends on the distribution of the shock across the MSOAs that make up the LAD.

[9]The steepness of the curve will depend on the willingness of unemployed LCS workers to commute as well as on capacity-constraints, etc. Marinescu and Rathelot (2018) show that in the US job-seekers are a around third less likely to apply to a job 10 miles away.

Figure 13:
The equilibrium in zone z prior to the Zoomshock. Right skewness.



Note: This figure illustrates possible Zoomshocks for eight zones across two fictional areas.

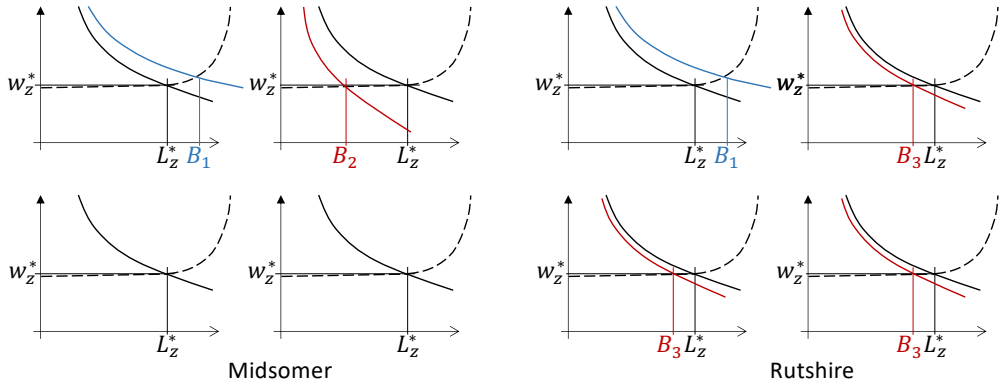
In Figure 13 we illustrate this for two fictional LADs, Loamshire and Wessex, each containing four MSOAs, one in each quadrant of the LAD. To highlight the aspects that affect the link between the overall effect of the Zoomshock and the shape of the distribution of these shocks in the area, we make assumptions which are deliberately extreme. The demand function for LCS (black solid curve) is identical in all eight areas, and so in the long run equilibrium each area has the same employment for LCS workers who are all paid the same wage. The eight demand and supply diagrams in Figure 13 depict the LCS market in each of these MSOAs.

We also posit the supply functions to be the same in the eight zones. This again is to highlight the role of skewness in the Zoomshock, and could be relaxed with no change in the results. What matters is that, beyond the pre-shock equilibrium the supply is convex; as we argue above, this is plausible. Figure 13

depicts a large decrease in demand (brought on by a negative Zoomshock) in the north-east MSOA of each of Loamshire and Wessex. In these zones, half the workers stop commuting there to work and instead work-from-home. This is represented by the demand function for LCS workers in these areas shifting to the red curve, where LCS labour demand at the previous salary, is exactly half as it was before. What distinguishes Loamshire and Wessex is where the teleworkers reside. In Loamshire they all live in the north-easterly MSOAs. In this MSOA the demand curve shifts to that of the blue line: the demand has increased by 50%, a rightward shift equal in size to the leftward shift of the red curve in the north-west. In the two other MSOA there is no change, as no one previously commuted to or from them, so the equilibrium in these two "southern" MSOAs is unaltered. The total employment of LCS workers in Loamshire changes by the difference between the the decrease in the north-west zone, the distance between L_z^* and A_1, and the increase in the north-east zone, the distance between A_2 and L_z^*. That, is, the total employment in Loamshire following the Zoomshock is $2L_z^* + A_1 + A_2$.

But now consider Wessex: here the workers who were commuting to the north-west zone and are now teleworking are evenly distributed across the rest of the LAD, so that in each of the three other MSOAs, the demand curve for LCS workers shifts by a third of the distance of the shift in the north-east MSOA in Loamshire, as depicted in the RHS panel of Figure 13. The analogous argument shows that the post-Zoomshock employment in Wessex is $A_1 + 3A_3$. The convexity of the supply of labour beyond the pre-Zoomshock equilibrium implies that the distance between A_2 and L_z^* is less than three times the distance between A_3 and L_z^*. This implies that the total loss of employment due to the

Figure 14:
The equilibrium in zone z prior to the Zoomshock. Left skewness.



Note: This figure illustrates possible Zoomshocks for eight zones across two fictional areas.

fact that workers cannot relocate frictionlessly between MSOAs is greater in Loamshire. Thus in the comparison between the two counties, the loss of LCS employment depends not on the magnitude of the aggregate Zoomshock, but on the skewness of the distribution of the shocks: Wessex's distribution is more skewed than Loamshire's (which is in fact symmetric).

The next figure shows however that it is only right skweness (that is positive skewness) that matters. In Midsomer, the shock pattern is symmetric, exactly the same as in Loamshire, whereas the county of Rutshire, has one MSOA with the same positive shock as Midsomer, the north-west in both counties, but smaller negative shocks in the three other MSOA, making the shock distribution in the county left skewed. Yet the overall impact on LCS employment is the same in Rutshire and in Midsomer, due to the linearity of the supply function to the left of the pre-shock equilibrium.

There are already two lessons to take from this preliminary analysis. The first is that, in aggregate, we expect the Zoomshock will lead to a decrease in LCS employment. This is a consequence of short-run labour market frictions and capital availability that mean a shift in LCS demand from one neighbourhood to another will not be mirrored by a similar shift supply. The second lesson is that we expect the consequences for employment across an LAD to be worse the more skewed is the Zoomshock across the MSOAs which make up the LAD.

5.1 The Zoomshock and Locally Consumed Services: Some Evidence

There is significant anecdotal evidence of the negative impact that the Covid-19 pandemic has had on the LCS industry, particularly in urban centres such as central London. Given the large negative Zoomshock we estimate for central London (Figure 6), this is not surprising. We now provide quantitative evidence as to the scale and distribution of this shock. As stated in the introduction, we define LCS as any good or service for which the market is geographically constrained, both supply and demand must take place in a fixed geographic location. Restaurants, hairdresser and theatres are obvious examples. Although the goods purchased in a department store are not part of locally consumed services *per se*, the service provided by the department store, providing an outlet and assistance in which to purchase goods, is a local service.[10] We define businesses and employees in the locally consumed service industry according to 615

[10]Our definition of local services is closely related to the *tradeable* and *non-tradeable* goods nomenclature, as in Mian and Sufi (2014).

four-digit Standardized Industry Classification codes.

The overall distribution is shown in Figure 15. Here we see that, both within the Greater London Area (left panel) and outside it (right panel), the proportion of MSOAs experiencing a negative shock is increasing with the number of the local service employees. That is, in our data, LCS employment is concentrated in neighbourhoods in which there are many jobs suitable for working-from-home. The average MSOA which experiences a positive Zoomshock has 687 employees working (pre-Covid-19) in LCS within the MSOA. The average MSOA experiencing a negative Zoomshock has 2139 employees working (pre-Covid-19) in LCS within the MSOA. Despite the fact that only 28% of MSOAs are predicted to experience a negative Zoomshock (1990 MSOAs), these MSOAs account for 54% of all the local service employment. Overall, in Britain 4,252,963 employees suffer a negative shock, against versus 3,583,376 employees in MSOAs experiencing a positive shock.

Figure 15 shows that a small number of MSOAs are experiencing very large Zoomshocks, an increase in employment in some cases of over 300%. These large changes are concentrated in the MSOAs with the fewest LCS employees. For most MSOAs experiencing a positive shock this is smaller, reflected by the mass of points just above the red-dashed horizontal line which separates positive and negative shocks. This combination implies the distribution of positive shocks to be characterised by most shocks being small and close to the mode, with a few large shocks far to the right. That is, right-skewed. Moreover, the largest shocks have been in MSOAs where the composition of employment suggests there is the least existing capacity. It is reasonable to suspect that this limited capacity will mean that there will be less ability to absorb these increases.

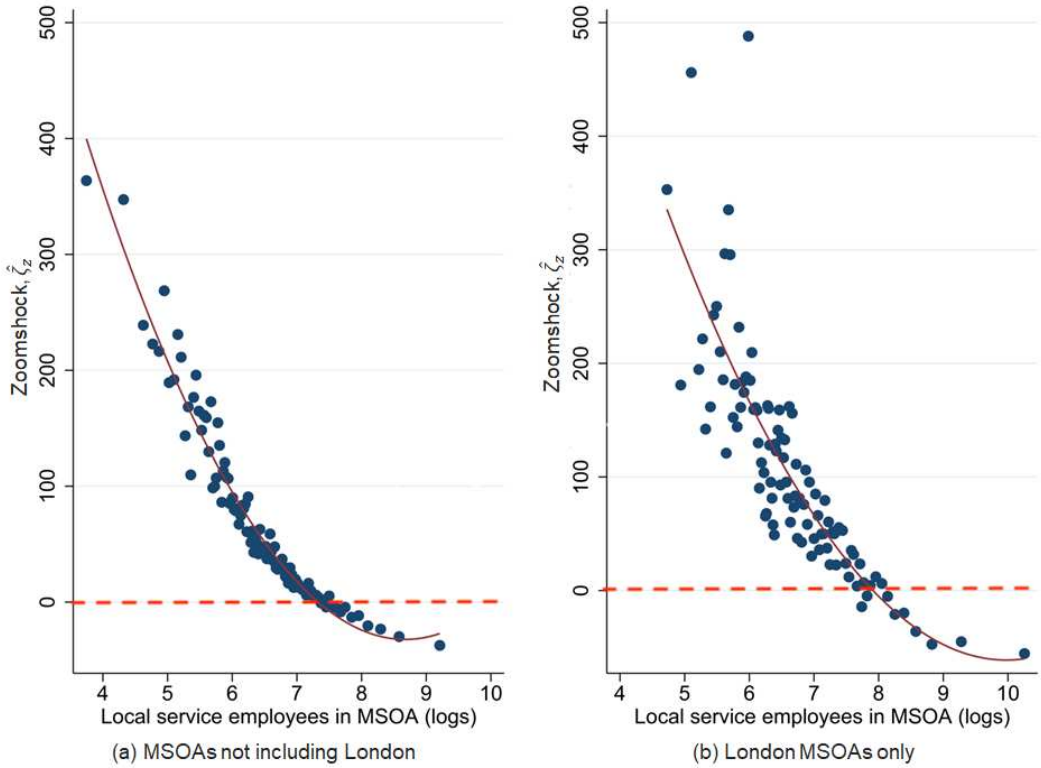
Recall from Figure 14, that while the data also show that distribution of negative shocks is also skewed—this is not what matters for the aggregate outcome. While, the right-most observations in the left and right panels represent an average of over 8,000 and 22,000 employees respectively it isn't the concentration of these losses, but rather the inability of MSOAs experiencing positive shocks to re-employ them that leads to the negative aggregate effect on LCS employment.

This is the UK government's official measure of relative deprivation. It is based on 39 separate indicators and aims to capture the lack of resources needed to meet needs across a wide range of an individual's living conditions, not just lack of financial resources.

We close our analysis by noting that the losses in LCS employment are likely to exacerbate geographic inequality. Figure 16 shows that LCS workers are disproportionately likely to live in MSOAs high Index of Multiple Deprivation scores.[11] In the most deprived MSOAs, roughly 45% of residents are employed in the LCS sector. Thus, the skewness of the negative shock distribution may not matter for the overall level of LCS employment losses, but to the extent that workers in MSOAs with the most negative shocks live in similar locations, we may expect the increase in poverty to be highly geographically concentrated. This concentration might have important policy implications.

[11]This is the UK government's official measure of relative deprivation. It is based on 39 separate indicators and aims to capture the lack of resources needed to meet needs across a wide range of an individual's living conditions, not just lack of financial resources.

Figure 15:
Zoomshock and local service employment

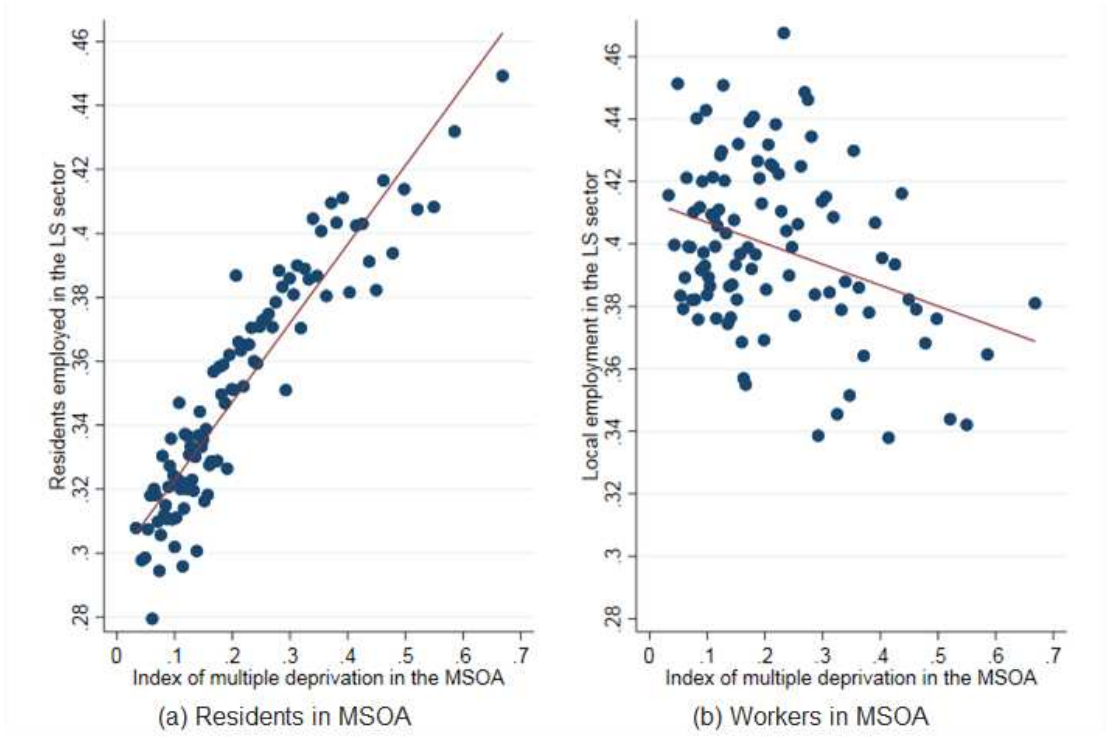


Note: This figure regresses, for each MSOA, the Zoomshock (Equation 4) against the log-employment in the local service industry. Binned into 100 evenly sized groups.
Data source: Change in MSOA employment based on authors' calculation using the ONS Annual Survey of Hours and Earnings, 2017, 2018, 2019. Log-employment in local services by MSOA calculated using information from the ONS Business Structure Database, 2018.

6 Conclusion

This paper looks at an important economic consequence of the Covid-19 pandemic. The pandemic has lead to a significant shift in the geographic distribution of economic activity as workers who can work from home, do so. We refer

Figure 16:
Index of Multiple Deprivation



Note: Binscatter plot: each of the dots represents many MSOAs, to avoid cluttering the diagram.
Data source: Percent employment in local services by MSOA calculated using information from the ONS Business Structure Database, 2018.

to this redistribution as the Zoomshock.

There are three takeaways from our results. First, the Zoomshock is large—many people can work form home and many people live in a different neighbourhood from the one where they work. This is true both for specific neighbourhoods and when we aggregate to the level of local authorities. Second, the Zoomshock is extremely heterogeneous. Within UK local authorities, some neighbourhoods have experienced a very large decline in economic activity

while others have seen a surge. In general, while the most prominent feature of the Zoomshock has been the relocation of economic activity from a few densely populated city centres to the suburbs, the precise changes are often quite different in seemingly similar neighbourhoods. Third, the Zoomshock is moving workers away from neighbourhoods with a large supply of locally consumed services to neighbourhoods where the supply of these services is relatively scarce. As LCS are, by definition, geographically immobile in the short-run, this suggests a possible geographic mismatch of supply and demand that may have consequences for aggregate LCS employment. We found that the scale of the losses depends crucially on the shape of the distribution of Zoomshocks, and in particular that what matters is the skewness of positive shocks. If the positive shocks are approximately uniformly distributed, then losses due to frictions, such as capacity constraints, will be lower than if the Zoomshock is concentrated on a small number of neighbourhoods. This makes it crucial to obtain a precise measure of the Zoomshock at a highly granular level.

An objective of this exercise is to produce guidance for policy makers in the UK, and in other countries, in the formulation of a Covid-19 economic recovery strategy. The exact nature of the policy prescription depends on how long-lived will be the increase in working-from-home. If we expect that once the UK emerges from the current public health crisis, workers will return to the office and pre-Covid-19 economic activities are restored, then there is a role for policy to aid local service businesses that are currently struggling to survive. In this case aid should focus in neighbourhoods which are experiencing the largest negative Zoomshocks. If, on the other hand, we expect a significant fraction of

work to continue to take place at home once public health restrictions are eased, then policy should encourage and facilitate LCS businesses relocating to where is the demand. That is, businesses in LCS industries should be encouraged to move from neighbourhoods experiencing large negative Zoomshocks to neighbourhoods with positive Zoomshocks. Further understanding of the impact of the Zoomshock on economic activity will also be needed in view of the fact that the different characteristics of the zones experiencing positive and negative Zoomshocks will affect their ability to support LCS businesses: for example a large café thriving in a busy city centre may not survive in a well-to-do sparsely populated rural environment.

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