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Working from Density

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Working from Density⁺

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January 27, 2023

Abstract

Is the COVID-19 driven surge in remote work temporary or permanent? To assess how the geography of work may evolve, we analyze the pre-pandemic status quo. Casual theorizing might suggest that workers with teleworkable jobs in the pre-pandemic era were more likely to live in the less dense, peripheral neighborhoods in their metropolitan area. Instead, we find that, for neighborhoods of almost all incomes, those with a greater share of teleworkable jobs were likely to be relatively high-density. Potential explanations include the complementarity of reduced commuting time with urban amenities, and the complementarity of telework with social interactions outside the home.

Keywords: Agglomeration, Amenities, Cities, Commuting, Telework, Work

JEL Codes: J32, J61, M50, O18, R12, R30, R41

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1. Introduction

The COVID-19 pandemic caused a dramatic surge in remote work (Althoff et al., 2020; Bick, Blandin, and Martens, 2020; Coven, Gupta, and Yao, 2020; Liu and Su, 2020; Barrero, Bloom, and Davis, 2020). There is evidence that the initial shift toward remote work increased housing prices significantly and that remote work yielded productivity increases (Emanuel and Harrington, 2020; Mondragon and Wieland, 2022; Bloom, Han, and Liang, 2022) and time savings (Aksoy et al., 2023). Whether or not this increase in remote work, which was driven largely by high-income workers, is a short blip or a lasting change remains an open question.

Understanding the future spatial pattern of worker residential location is crucial for policymakers. Without understanding the spatial organization of workers' residences, policymakers are ill-equipped to make decisions about urban infrastructure, affordable housing, and land use planning in the years ahead.

We look at the status quo prior to the pandemic to assess what the geography of work may look like in the future. The downside to this approach is obvious: in 2019, remote work had not yet gained the popularity it enjoys now. But this approach has a clear advantage: living and working patterns as they existed in 2019 reflected long-term equilibrium responses to the possibility of telework in many occupations. This is a clear contrast to the current situation of partial adjustment to the once-in-a-generation macroeconomic and public-health upheaval wrought by COVID-19.

Specifically, we explore the relationship between neighborhood population density and the share of workers with the potential to telework. We might expect the ability to telework in the pre-pandemic era to be prominent in less-dense, peripheral neighborhoods within each metro area, reflecting the lesser importance of a short commute to workers who can work remotely. Instead,

we find that, at least within the three top income quartiles, a strongly positive relationship between the share of teleworkable jobs and neighborhood density.¹

One potential explanation for this pattern is the complementarity between leisure and amenities such as restaurants, theaters, and museums, that are oftentimes located in denser places. In addition, if workers telework frequently, they might place a higher value on interactions outside the workplace with people other than members of their household, be they for purely social reasons or for professional purposes. These in-person interactions may be more easily found in denser places.

The remainder of this paper proceeds as follows. In Section 2 we describe the data we use in our analysis. In Section 3 we analyze the basic relationship between teleworkability and density, while Section 4 explores how the relationship between teleworkability and income complicates this relationship. We conclude in Section 5.

2. Data

Our goal is to extract lessons from pre-COVID pandemic patterns in the geography of telework potential, and to make a small-neighborhood measure of income, teleworkability, and population density. To this end, we rely on datasets that do not incorporate the radical reorientation of many employment arrangements that occurred during and after 2020. At the core of our analysis is the Longitudinal Employer-Household Dynamics Origin-Destination Employment Statistics Resident Area Characteristics (LODES) dataset from 2019, which we use to measure industry employment

¹ Dingel and Neiman (2020) use the term “jobs that can be done at home”; for parsimony we refer to these same jobs as “teleworkable.”

by Census block group.² We then combine this dataset with block group median household income data from the 2015-2019 pooled American Community Survey (ACS) and an estimate of the share of workers with “jobs that can be done at home” by two digit NAICS industry (Dingel and Neiman, 2020). We limit our attention to the 186,978 block groups for which we have complete data and that fall within the 902 metropolitan statistical areas (MSAs) identified in the LODES dataset. Our final sample of block groups includes about 88 percent of the US population in 2019.³

Our main outcome of interest is the share of teleworkable jobs. Dingel and Neiman (2020) use surveys from the US Department of Labor’s O*Net database to assess which occupations could be carried out remotely and summarize their findings as shares of workers that could work from home by 2-digit NAICS sector. Using these data for each block group, we multiply the national 2-digit share of workers with teleworkable jobs in industry j by the total number of workers in industry j in block group i . This gives us the total number of workers with teleworkable jobs across all industries in a block group. Given this estimate of the total number of workers in block group j with teleworkable jobs, we also calculate the share of all workers residing in block group j with teleworkable jobs. For the average block group in our sample, we find that 36.5 percent of workers can telework, quite similar to Dingel and Neiman (2020)’s reported national average estimate of 37 percent.

Turning to predictors, we are primarily interested in the relationship between teleworkable jobs and population density, which we measure using persons per square mile. We then characterize relative population density using two methods. First, we assign each block group to

² A block group is a small neighborhood – smaller than a tract, but larger than a Census block – defined by the Census. The Census designs block groups so that they contain between 600 and 3,000 residents. See https://www.census.gov/programs-surveys/geography/about/glossary.html#par_textimage_4. We use neighborhood and block group interchangeably.

³ We drop 32,783 block groups because they are not within one of the 902 MSAs. We drop an additional 14 block groups due to missing data. Our final sample includes 85 percent of all block groups.

its centile in the national distribution of population density. This measure of density captures differences across as well as within the 902 metropolitan areas in our sample. Second, we assign each block group to its centile in its metropolitan area's population density distribution. By construction, this measure assigns the densest block group in Bozeman, MT and the densest block group in New York City, NY to the same centile. Thus, the first measure yields a neighborhood's rank in the national population density distribution, and the second a neighborhood's rank in the its own metropolitan area's population density distribution.

In addition to density, we are also interested in income. We measure income as the ACS's block group level median household income in 2019 nominal US dollars. We next assign each block group to its within-metropolitan area income quartile. By construction, the income boundaries of the top quartile in Bozeman, MT are lower than those of New York, NY. On average, across all block groups, the median household income by quartile is \$36,800, \$56,900, \$76,400, and \$115,700, respectively.

3. Working from Density

In the classic Alonso-Muth-Mills monocentric city model, workers' location choices are primarily driven by a tradeoff between housing consumption and commuting cost (Alonso, 1964; Mills, 1972; Muth, 1969; Anas, Arnott, and Small, 1998). If workers who can telework have less costly commutes at any location, this governing tradeoff suggests that workers who can telework value the more expensive housing near the job-dense city center less than other workers. This leads workers who can telecommute to select housing in lower-density areas. However, when we graph the relationship between the block group share of teleworkable jobs and density in Figure 1, we

see the opposite relationship. The horizontal axis reports the centile of population density. The vertical axis reports the share of teleworkable jobs. Each point the graph reports is the average of all block groups in a given density centile. There is a clear positive relationship between telework potential and density across metropolitan areas. The relationship is steeply upward sloping through about the fiftieth percentile, flat from about the fiftieth to the 90th percentile and then again steeply upward sloping at about the 90th percentile.⁴

An obvious explanation for the positive relationship between teleworkable jobs and block group density nationally is that workers sort across labor markets. That workers in high-skilled, knowledge intensive jobs sort into larger, denser, metropolitan areas is well documented (Moretti, 2012; Eckert, Ganapati, and Walsh, 2020). Moreover, Dingel and Neiman (2020) identify “managers, educators, and those working in computers, finance, and law” as occupations that can typically work from home. These teleworkable occupations have significant overlap with the group of knowledge-intensive “skilled scalable services” that Eckert, Ganapati, and Walsh (2020) associate with a disproportionate share of urban growth since 1980.

Because the relationship in Figure 1 could be driven by the overrepresentation of high-skilled knowledge workers in dense metropolitan areas, we turn our attention to the relationship between teleworkability and density *within* metropolitan areas. The horizontal axis of Figure 2 reports within-metro area population density centiles (we call these the “relative density” centiles); the vertical axis again reports the share of teleworkable jobs. Each dot reports the average teleworkable share for all block groups in a relative density centile. The positive national relationship between density and telework becomes more nuanced as we focus our attention within metros. Again, for low relative densities, below the 35th density percentile, there is a strong positive

⁴ We restrict our attention to block groups located within metropolitan statistical areas throughout this paper. However, including all block groups nationally does not alter our findings in Figure 1.

relationship between density and telework. However, between the 35th and 85th percentiles, the share of teleworkable jobs decreases with density. Above the 85th percentile, the relationship between density and teleworkability is once again positive. The erosion of the national relationship between density and telework when we focus on the within-metro relationship suggests that sorting of workers across metropolitan areas drives the relationship between density and telework in Figure 1.

The undulating relationship we uncover in Figure 2 does not neatly fit the predictions of the monocentric city model. If teleworkable jobs are correlated with both higher incomes and lower commuting costs, we would expect a negative relationship between density and income (Anas, Arnott, and Small, 1998).⁵ We see such a relationship only for block groups in the middle of the density distribution. In the next section we therefore explore the role of income in more detail.

4. Telework and Income

A neighborhood's share of teleworkable jobs is likely associated with the share of higher-income occupations in that neighborhood, as discussed in the previous section. Income also impacts location decisions even within metropolitan areas (Anas, Arnott, and Small, 1998; Dingel and Neiman, 2020). To assess the extent to which income drives the relationship between teleworkability and density, we bring income directly into the analysis.

Figure 3 repeats the analysis of Figure 2 but, rather than using the average across all block groups for a given centile, reports the average teleworkability share by centile and by income

⁵ Brueckner (2011) notes that in a monocentric model with heterogeneous households, the location of rich and poor will be governed by the relative strengths of the demand for housing and the desire to minimize the cost of commuting for both groups. The predictions of this model for location by income are ambiguous.

quartile. That is, for each centile we calculate four separate averages, one for each income quartile. Each point in Figure 3 thus represents the average teleworkable share for all block groups in a given income quartile and relative density centile. Whereas in Figure 2 each point was an average of the same number of block groups, in this figure each dot is the average of a varying number of block groups.

Within each income quartile, we find a positive relationship between density and telework. The higher the income quartile, the more pronounced the relationship between density and teleworkability. This finding is surprising in the following sense: residents in the densest block groups, those closest to central business districts and workplaces, have a higher share of teleworkable jobs.⁶

Any interpretation of Figure 3 depends on where workers in a given income quartile live. For example, are there many workers in the lowest income quartile in a metropolitan area's densest block groups? We use Figure 4 to explore the within-city location choices of workers by income quartile. The horizontal axis reports the relative density percentile and the vertical axis the group's population share for that centile. The figure displays the share of workers in each income quartile in a relative population density centile. For example, if workers in any income quartile were evenly distributed across all metropolitan area densities, the line for that income quartile would be horizontal at 0.01.⁷ The area under each quartile's line integrates to 1, since the sum of the share of workers across all neighborhoods within an income quartile sums to one.

⁶ Figure 3 also confirms that teleworkability is stratified by income. For any given centile of the within metro population density distribution, the higher the income quartile, the greater the average block group's teleworkability.

⁷ We divide our sample of block groups along two dimensions: their within-metro income quartile and their within-metro density centile. This division yields a total of 400 (unequal) bins. Using these bins, we first show the share of teleworkable jobs within each bin. For each of the 400 density by income block group bins, we divide the number of workers in that bin by the total number of workers in its income quartile. This gives us the share of the population within each income quartile by density centile.

Figure 4 tells us that workers' residential location differs substantially by income quartile. Workers in the lowest income quartile are overrepresented in dense block groups and underrepresented in the least dense ones. In contrast, workers in the three highest income quartiles are overrepresented in the least dense locations within their metropolitan areas. Putting these findings together with Figure 3, we conclude that the distribution of occupations across income groups likely explains why we see more workers in teleworkable jobs in denser block groups.

We now turn to regression analysis to give overall estimates for the strength of this relationship, and to assess statistical significance. Table 1 reports estimates of regressions of the form

$$\begin{aligned}
 YesTelework_{igm} = & \alpha + \beta * \ln(Density_{igm}) + \sum_{g=2}^4 [\gamma_g * \ln(Density_{igm}) * 1\{IncQuartile_g\}] + MSAFES_m \\
 & + IncQuartileFES_g + \varepsilon_i
 \end{aligned}$$

where $YesTelework_{igm}$ is the share of teleworkable jobs in block group i , within-metro income quartile g , and metropolitan area m . $Density_{igm}$ is thousands of persons per square mile. $IncQuartile_g$ is a vector of three indicator variables for the within-metro area income quartiles. $MSAFES_m$ and $IncQuartileFES_g$ are MSA fixed effects and within-metro area income quartile fixed effects. We cluster robust standard errors at the metropolitan area level.

Column 1 of Table 1 follows Figure 1, estimating the relationship between density and teleworkability. We find a positive and statistically significant relationship between density and telework nationally. Moving from the 25th density percentile to the 75th density percentile is

associated with a 1.1 percentage point increase in the share of teleworkable jobs, or a 3 percent increase relative to the mean of 36.5 percentage points.⁸

Column 2 mimics the intra-metropolitan comparison in Figure 2 by adding metropolitan area fixed effects. This inclusion reverses the findings in column 1. The coefficient on density in column 2 is negative and significant, and much smaller in magnitude than in column 1.

Finally, in column 3, we include both metropolitan area and within metropolitan area income quartile fixed effects, as well as the interaction between the second, third, and highest within metro income quartiles and population density. This approach parallels Figure 3. The average neighborhood in all income quartiles besides the lowest is more likely to have a greater share of teleworkable jobs if it is higher density.

All the interaction coefficients are statistically significant and imply that this relationship strengthens as income increases. These findings suggest that for block groups in the top income quartile, a change from the 25th density percentile to the 75th density percentile increases the share of teleworkable jobs by 1.6 percentage points, or 4 percent relative to the group mean of 39.6. Additionally, our model in column 3 explains over 58 percent of the variation in teleworkable jobs across block groups.

5. Conclusion

We find that, for neighborhoods in the same metropolitan area income quartile, the denser the block group, the higher the share of teleworkable jobs. This surprising finding could arise for a number of reasons.

⁸ The 25th density percentile block group has 1,700 people per square mile, and the 75th density percentile block group has 10,300 people per square mile.

First, if workers in industries with greater telework potential enjoy more leisure time in equilibrium, their willingness to pay for amenities that complement leisure increases, and such amenities may not be available in lower-density areas.

Second, if workers value social interactions, and interactions at work are less frequent, they may seek out social interaction in non-work settings. Non-work social interactions are more readily found in population dense areas.

Third, and similarly, if in-person contact drives agglomeration effects, a shift to remote work makes such contact outside the work place more valuable. Again, in-person contact is easier in more population dense-areas. All of these explanations point toward increased telework leading to a greater willingness to pay for housing in high density places.

It is important to note that the contours of the post-COVID geography of work will also be shaped by the work arrangements firms implement. First, firms could require workers to return to the pre-COVID status quo. This arrangement would make the pre-COVID distribution of housing locations very informative about the post-COVID distribution.

At the opposite extreme, firms could allow workers to “work from anywhere.” There is some evidence that for certain types of workers this may be a productivity increasing arrangement (Choudhury et al., Forthcoming). Our findings suggest that this change might increase the amount of amenity rich housing in denser areas, as these workers look for amenities and social and professional interactions outside of the workplace. However, these location choices would not be bound to current high-employment metros, and there is the potential for less expensive metropolitan areas to gain workers.

A middle path involves hybrid work arrangements, in which firms allow workers to telework a few days per week, and ask them to come into the office on the other days. There is

suggestive evidence that the hybrid arrangement will be the dominant post-COVID policy for workers in occupations that lend themselves to telework, and that hybrid arrangements also offer benefits to firms (Barrero et al., 2020, Bloom et al., 2022). This hybrid setting may drastically reduce total commute times (cf. Aksoy et al., 2023), which would lower the cost of living far from the city center. However, as in the work from anywhere arrangement, there may be an upward shift in the demand for amenities and social and professional interactions outside the office that makes denser places more valuable. Compared to the scenario in which firms allow workers to work from anywhere, hybrid arrangements will generate less redistribution of workers across metropolitan areas.

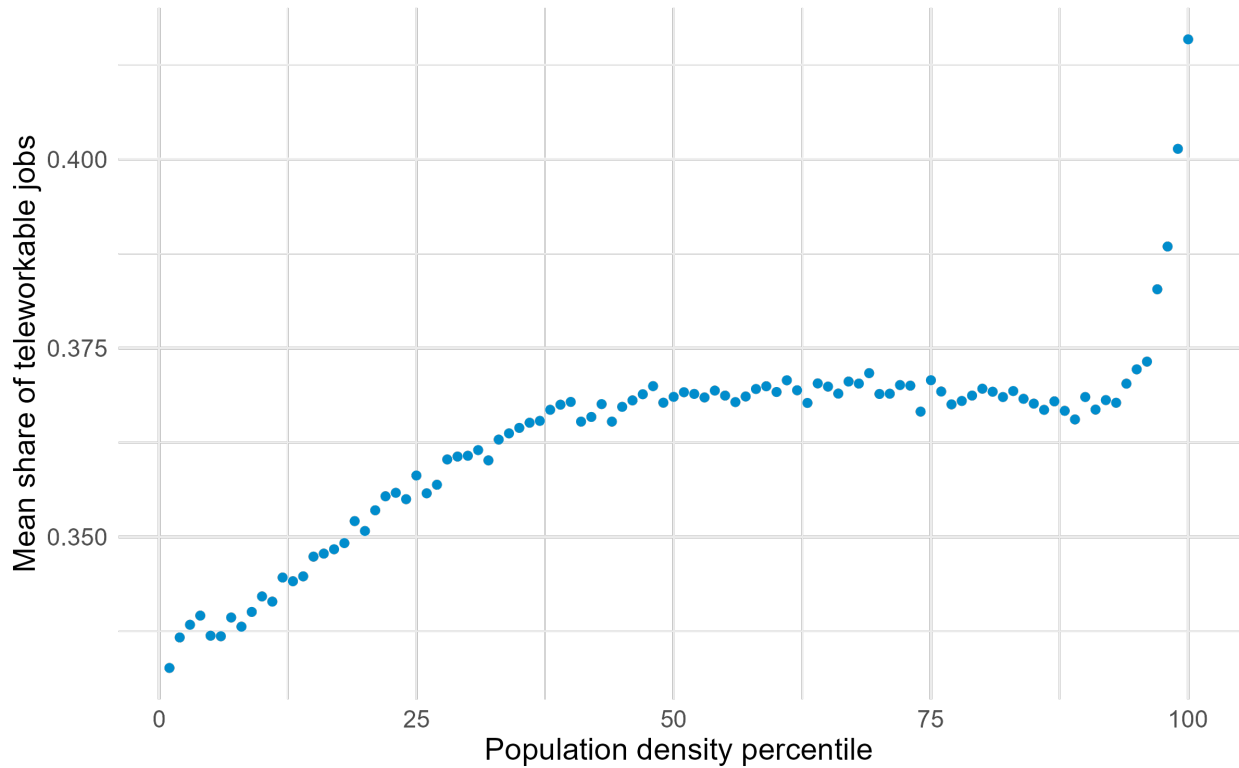
Regardless of which density-oriented considerations and telework arrangements turn out to be most important in different contexts, the central takeaway from the pre-pandemic era highlighted here will undoubtedly remain true. The mere fact that workers with teleworkable jobs can live in more remote, less dense areas does not mean that they will.

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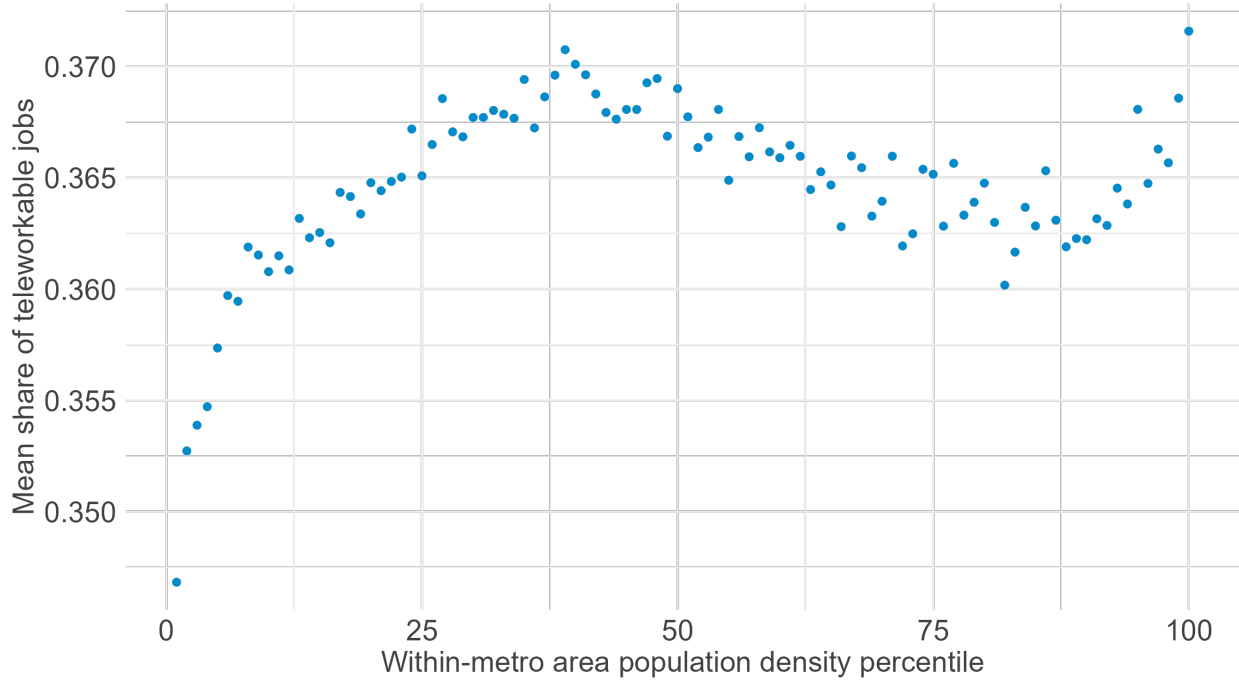
Exhibits

Figure 1: National Relationship between Block Group Density and Telework



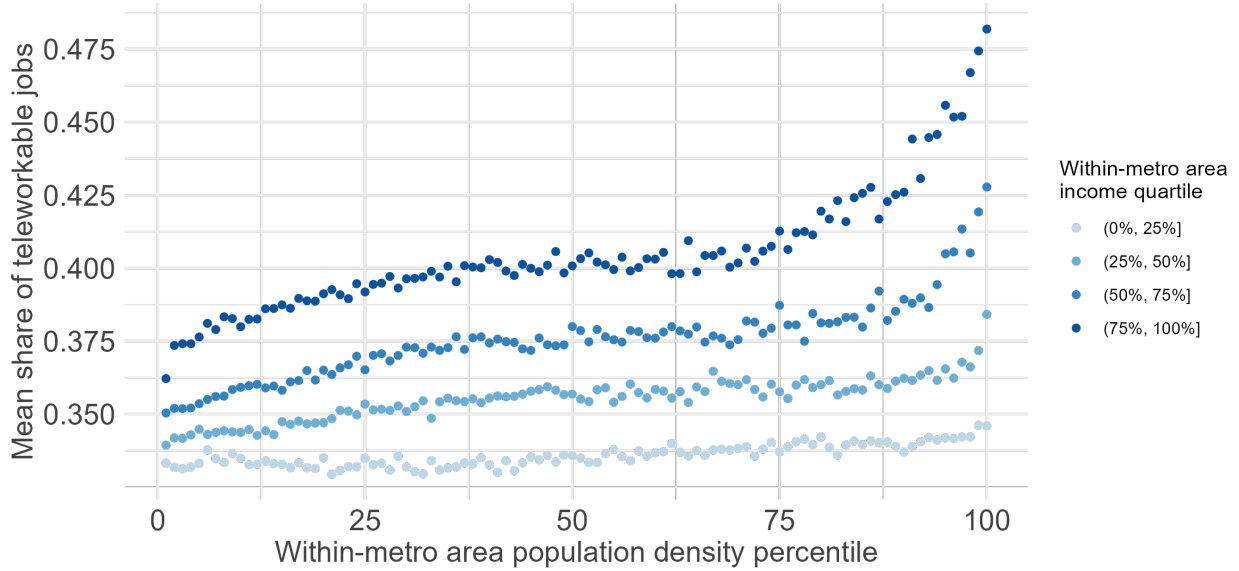
Note: Each blue dot in this figure is an average share of teleworkable jobs, for all block groups in the national population density distribution centile on the horizontal axis. The lowest-density block groups have density percentile rank of 1, and the densest block groups have density percentile rank 100. We use only block groups in metropolitan areas, which we identify using the US Census Bureau's Core-based Statistical Areas. We obtain data on telework potential from Dingel and Neiman (2020), industry of employment for residents by block group from the 2019 LODS Resident Areas Characteristics data, and population and land area from the 5-year 2015 to 2019 American Community Survey.

Figure 2: Within-Metro Area Relationship between Block Group Density and Telework



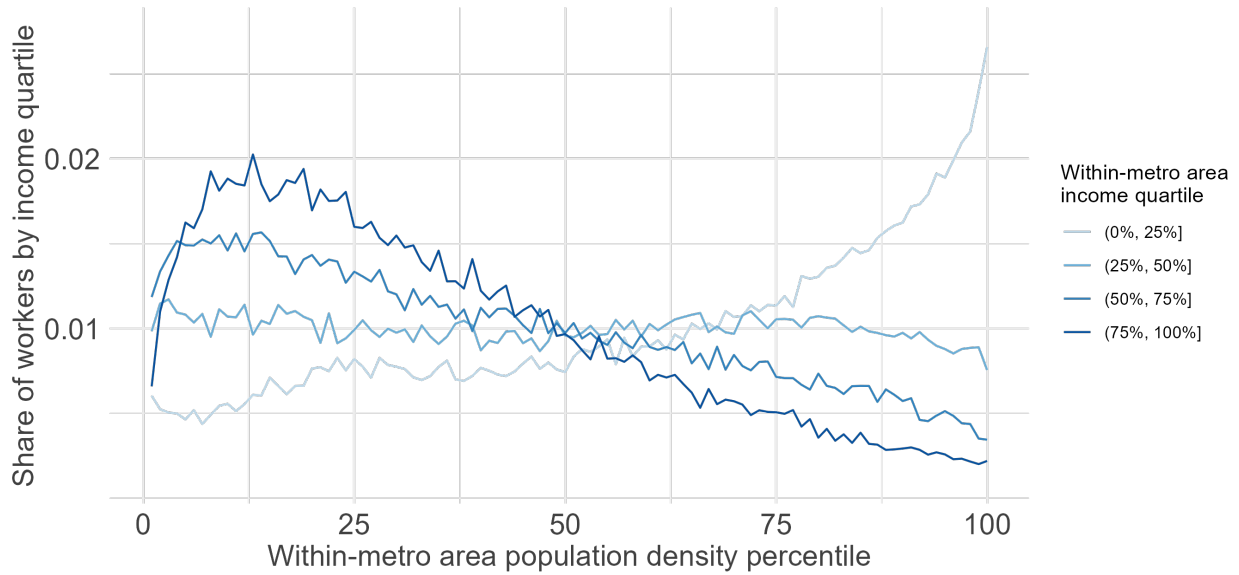
Note: Each blue dot in this figure is an average share of teleworkable jobs, for all block groups in the within metropolitan area population density distribution centile on the horizontal axis. By “within metropolitan area population density” we mean the distribution of block group density for each metropolitan area individually, rather than relative to the national distribution as in Figure 1. The lowest-density block groups have density percentile rank of 1, and the densest block groups have density percentile rank 100. We obtain data on telework potential from Dingel and Neiman (2020), industry of employment for residents by block group from the 2019 LODES Resident Areas Characteristics data, and population and land area from the 5-year 2015 to 2019 American Community Survey.

Figure 3: Within-Metro Area Relationship between Block Group Density and Telework by Income Quartile



Note: Each dot in this figure is the average share of teleworkable jobs for all block groups in the within-metro population density centile on the horizontal axis and income quartile as denoted by dot color. Population density centile in this figure is measure relative to the metropolitan area in which the block group is located. The lowest-density block groups have density percentile rank of 1, and the densest block groups have density percentile rank 100. We obtain data on telework potential from Dingel and Neiman (2020), industry of employment for residents by block group from the 2019 LODES Resident Areas Characteristics data, and population, land area and income from the 5-year 2015 to 2019 American Community Survey.

Figure 4: Within-Metro Area Distribution of Workers by Population Density Percentile and Income Quartile



Note: This figure shows the distribution of population within each income quartile by within metropolitan area density. If workers in a given income quartile were located uniformly across metropolitan areas, the distribution line would be horizontal at a share of 0.01. The area under each income quartile line integrates to 1 by construction. Population density centile in this figure is measure relative to the metropolitan area in which the block group is located. The lowest-density block groups have density percentile ranks of 1, and the densest block groups have density percentile rank 100. Data on telework potential by industry is from Dingel and Neiman (2020), workers by industry in each block group is from the 2019 LODES Resident Area Characteristics data, and the population is from the 5-year 2015-2019 American Community Survey.

Table 1: Estimates of the Relationship between Telework and Density

	Share of teleworkable jobs		
	(1)	(2)	(3)
Ln density	0.006*** (0.0001)	-0.001** (0.0005)	-0.003** (0.0004)
Ln density x 1 {MSA Income Q2}			0.004** (0.0003)
Ln density x 1 {MSA Income Q3}			0.007** (0.0004)
Ln density x 1 {MSA Income Q4}			0.012** (0.001)
MSA Fixed Effects		Y	Y
Income Quartile Fixed Effects			Y
Observations	186,978	186,978	186,978
R-squared	0.045	0.384	0.588

Note: * p < 0.1, ** p < 0.05, *** p < 0.01. This table reports estimates of equations of the following form:

$$YesTelework_{igm} = \alpha + \beta * \ln(Density_{igm}) + \sum_{g=2}^4 [\gamma_g * \ln(Density_{igm}) * 1\{IncQuartile_g\}] + MSAFES_m + IncQuartileFES_g + \varepsilon_i$$

where $YesTelework_{igm}$ is the share of teleworkable jobs in block group i , income quartile g , and metropolitan area m . $Density_{igm}$ is thousands of persons per square mile. $IncQuartile_g$ is a series of four dummies, one for each income quartile. We drop the lowest income quartile, which becomes our comparison case. $MSAFES_m$ and $IncQuartileFES_g$ are metropolitan area and income quartile fixed effects. Column 1 reports estimates for the bivariate relationship between density and teleworkability. Column 2 adds in metropolitan area fixed effects. Column 3 includes both metropolitan area and income quartile fixed effects, as well as the interaction terms between the second, third, and highest income quartiles and population density. Robust standard errors, clustered by metropolitan area, are in parentheses. We obtain data on telework potential from Dingel and Neiman (2020), industry of employment for residents by block group from the 2019 LODES Resident Areas Characteristics data, and population, land area and income from the 5-year 2015 to 2019 American Community Survey.