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Working from Density

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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.

The COVID-19 pandemic caused a dramatic surge in remote work (Althoff et al. 2022; Bick, Blandin, and Martens 2023; Coven, Gupta, and Yao 2023; Liu and Su 2021; 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 2023; Mondragon and Wieland 2022; Bloom, Han, and Liang 2022) and time savings (Aksoy et al. 2023). Whether 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 workers' 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 before the pandemic to assess how the geography of work may look 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 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, at least in 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, which are often 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 professional purposes. These in-person interactions may be more easily found in denser places.

The remainder of this report proceeds as follows. In the next section, we describe the data we use in our analysis. Then we analyze the basic relationship between the ability to telework and density, and the following section explores how the relationship between the ability to telework and income complicates the previous relationship. We conclude in the last section.

Data

Our goal is to extract lessons from pre-COVID pandemic patterns in the geography of telework potential and 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 (LODES) Residence Area Characteristics dataset from 2019, which we use to measure industry employment by Census Bureau block group.[2] We then combine this dataset with block-group median household income data from the 2015–19 pooled American Community Survey and an estimate of the share of workers with "jobs that can be done at home" by two-digit North American Industry Classification System (NAICS) industry code (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 2019 US population.[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 who could work from home by two-digit NAICS sector. Using these data for each block group, we multiply the national two-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 i with teleworkable jobs, we also calculate the share of all workers residing in block group i 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's (2020) 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 its centile in the national distribution of population density. This measure of density captures differences across and within the 902 metropolitan areas in our sample.

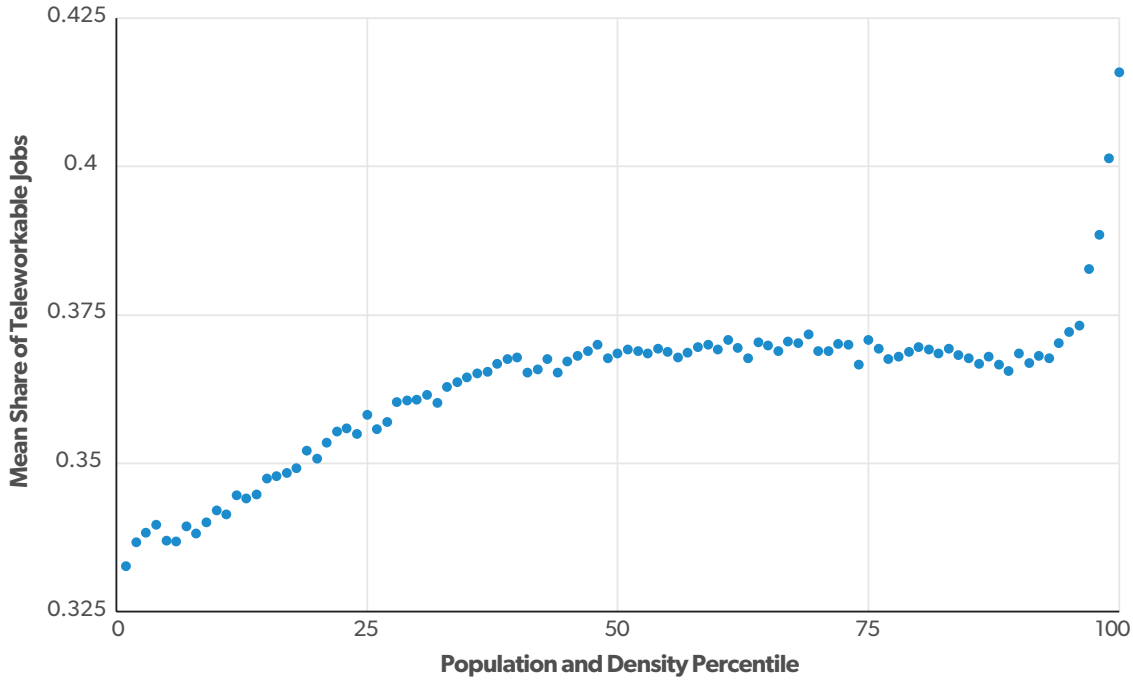
Second, we assign each block group to its centile in its metropolitan area's population density distribution. By construction, this measure assigns the densest block group in Bozeman, Montana, and the densest block group in New York City to the same centile. Thus, the first measure yields a neighborhood's rank in the national population density distribution, and the

[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."

[2] A block group is a small neighborhood—smaller than a tract but larger than a Census block—defined by the US Census Bureau. The Census Bureau designs block groups so that they contain between 600 and 3,000 residents. See US Census Bureau (2022b). 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.

Figure 1. National Relationship Between Block-Group Density and Telework



Note: Each blue dot 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 ranks of 1, and the densest block groups have density percentile ranks of 100. We use only block groups in metropolitan areas, which we identify using the US Census Bureau's Core-Based Statistical Areas.
Source: Data on telework potential are from Dingel and Neiman (2020). Data on the industry of employment for residents by block group are from US Census Bureau (2021). Data on population and land area are from US Census Bureau (2022a).

second measure yields a neighborhood's rank in its own metropolitan area's population density distribution.

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

Working from Density

In the classic Alonso-Muth-Mills monocentric city model, workers' location choices are primarily driven by a trade-off 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 trade-off suggests that workers who can telework value more expensive housing near the job-dense city center less than other workers do. This leads workers who can telework 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 50th percentile, flat from about the 50th to the 90th percentile, and then again steeply upward sloping at about the 90th percentile.[4]

[4] We restrict our attention throughout this report to block groups located in MSAs. However, including all block groups nationally does not alter our findings in Figure 1.

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 (2022) 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 (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 metropolitan areas. Again, for low relative densities, below the 35th density percentile, there is a strong positive 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 area relationship suggests that sorting 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.

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 influences 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 income 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.

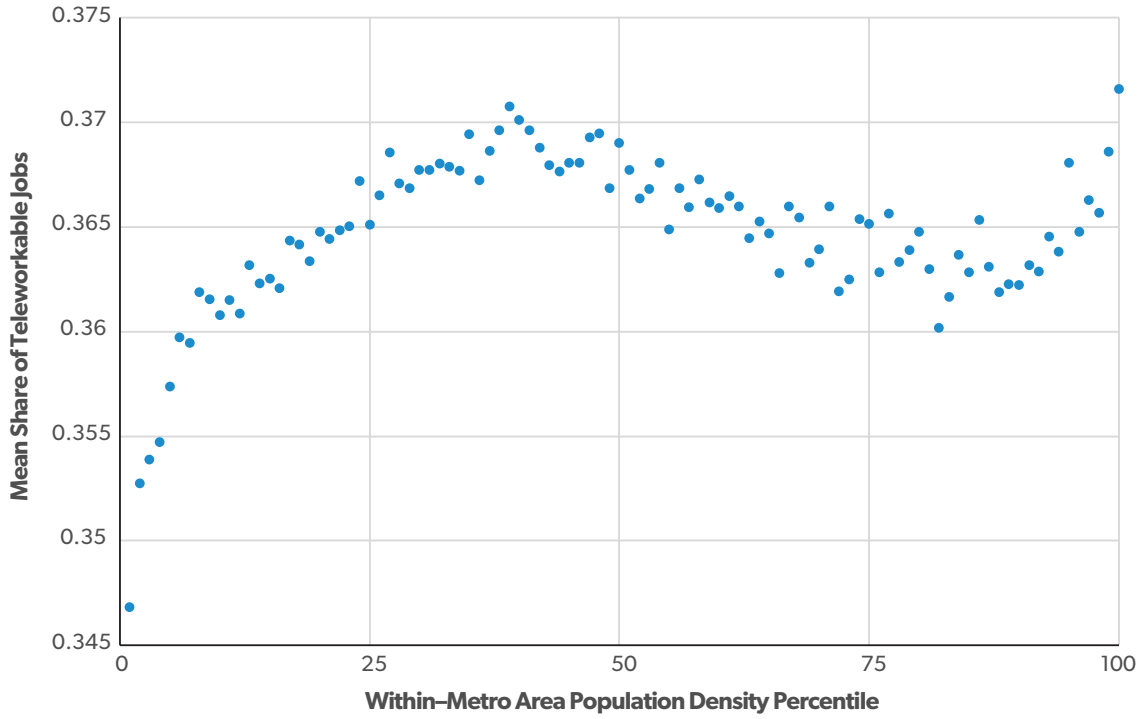
Within each income quartile, we find a positive relationship between density and telework. The higher the income quartile, the more pronounced the relationship between density and teleworkability. This finding is surprising in the following sense: Residents in the densest block groups, those closest 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

[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. This model's predictions for location by income are ambiguous.

[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 telework.

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 ranks of 1, and the densest block groups have density percentile ranks of 100.
Source: Data on telework potential are from Dingel and Neiman (2020). Data on the industry of employment for residents by block group are from US Census Bureau (2021). Data on population and land area are from US Census Bureau (2022a).

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 1.

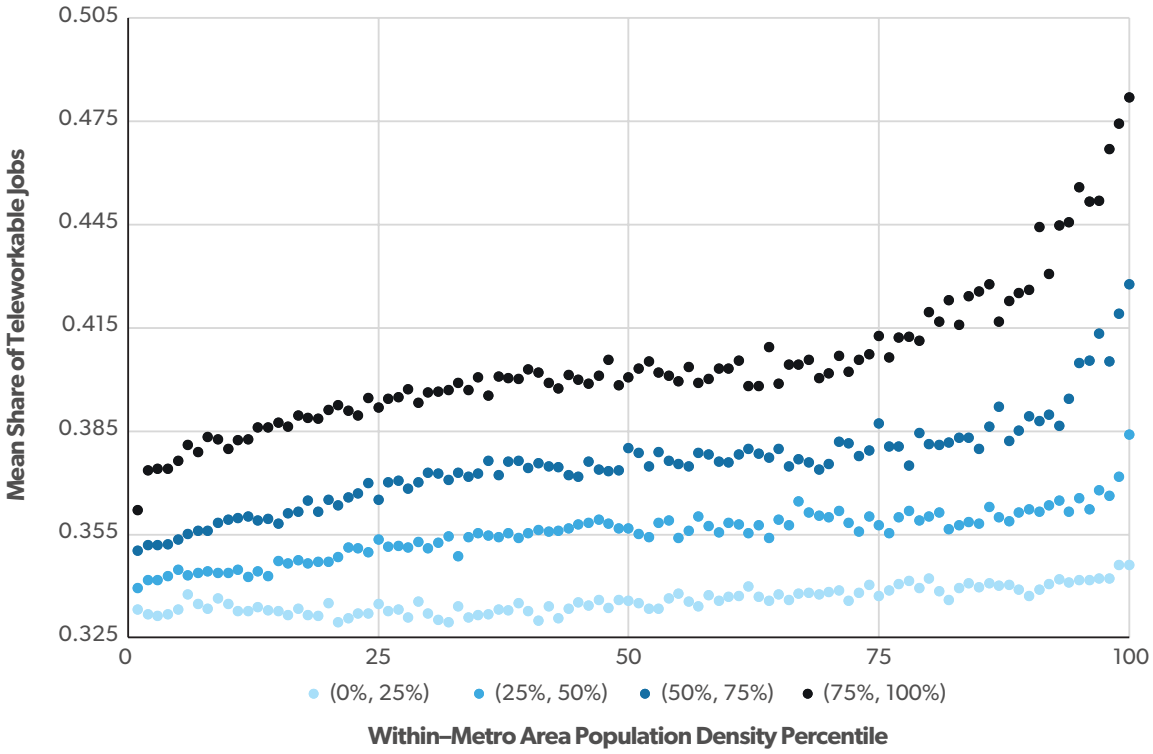
Figure 4 tells us that workers' residential location differs substantially by income quartile. Workers in the lowest income quartile are overrepresented in dense block groups and underrepresented in the least dense ones. In contrast, workers in the three highest income quartiles are overrepresented in 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 explains why we see more workers in teleworkable jobs in denser block groups, but not to the extent Figure 3 might lead one to expect.

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

$$YesTelework_{igm} = \alpha + \beta * \ln(\text{Density}_{igm}) + \sum_{g=2}^{4} [\gamma_g * \ln(\text{Density}_{igm}) * 1\{IncQuartile_g\}] + MSAFEs_m + IncQuartileFEs_g + \varepsilon_{igm}$$

[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 400 (unequal) bins. Using these bins, we first show the share of teleworkable jobs in 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 in each income quartile by density centile.

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 area population density centile on the horizontal axis and income quartile as denoted by dot color. Population density centile in this figure is measured relative to the metropolitan area where the block group is located. The lowest-density block groups have density percentile ranks of 1, and the densest block groups have density percentile ranks of 100.
Source: Data on telework potential are from Dingel and Neiman (2020). Data on industry of employment for residents by block group are from US Census Bureau (2021). Data on population, land area, and income are from US Census Bureau (2022a).

where $YesTelework_{igm}$ is the share of teleworkable jobs in block group i, within–metro area income quartile g, and metropolitan area m. Rather than the centiles in the figures above, we now measure density, $Density_{igm}$, as the log of 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 $IncQuartile_g$ are MSA fixed effects and within–metro area income-quartile fixed effects. We cluster robust standard errors at the metropolitan-area level.

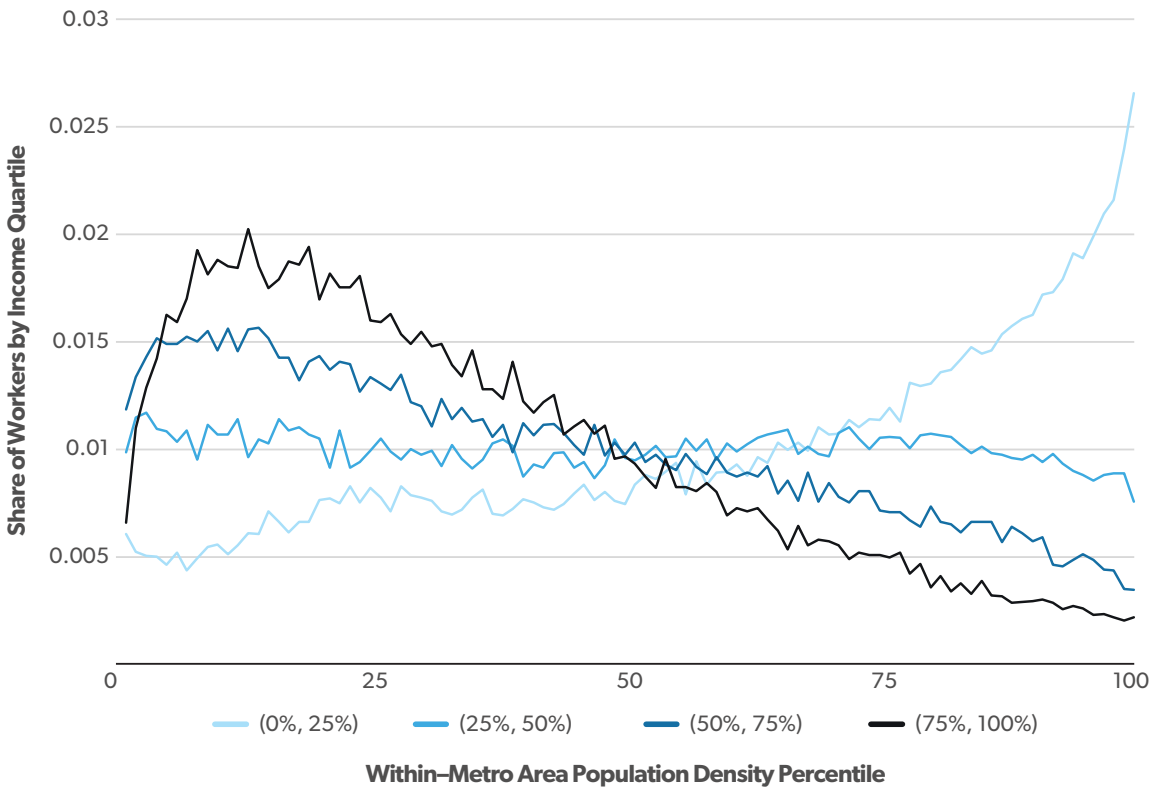
Column 1 of Table 1 follows Figure 1, estimating the relationship between density and teleworkability. We find a positive and statistically significant relationship between density and telework nationally. Moving from the 25th density percentile to the 75th density percentile is associated with a 1.1 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, 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 area income

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.

Figure 4. Within–Metro Area Distribution of Workers by Population Density Percentile and Income Quartile



Note: This figure shows the distribution of population in 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 measured relative to the metropolitan area where the block group is located. The lowest-density block groups have density percentile ranks of 1, and the densest block groups have density percentile ranks of 100.
Source: Data on telework potential by industry are from Dingel and Neiman (2020). Data on workers by industry in each block group are from US Census Bureau (2021). Population data are from US Census Bureau (2022a).

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.

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.

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 interactions in nonwork settings. Nonwork social

Table 1. Estimates of the Relationship Between Telework and Density

	Share of Teleworkable Jobs		
	(1)	(2)	(3)
Ln Density	0.006***	0.001**	0.003**
	(0.0001)	(0.0005)	(0.0004)
Ln Density x 1 {MSA Income Q2}			0.004**
			(0.0003)
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:

$$YesTelework_{igm} = \alpha + \beta * \ln(\text{Density}_{igm}) + \sum_{g=2}^{4} [\gamma_g * \ln(\text{Density}_{igm}) * 1\{IncQuartile_g\}] + MSAFEs_m + IncQuartileFEs_g + \varepsilon_{igm}$$

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 population density and the second, third, and highest income quartiles. Robust standard errors, clustered by metropolitan area, are in parentheses.
Source: Data on telework potential are from Dingel and Neiman (2020). The industry of employment for residents by block group is from US Census Bureau (2021). Data on population, land area, and income are from US Census Bureau (2022a).

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 workplace more valuable. Again, in-person contact is easier in more population-dense areas. All these explanations point toward increased telework leading to a greater willingness to pay for housing in high-density places.

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, Foroughi, and Larson, 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 the workplace. However, these location choices would not be bound to current high-employment metro areas, 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, Bloom, and Davis 2020; Bloom,

Han, and Liang 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, making 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 telework-able jobs can live in more remote, less dense areas does not mean they will.

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