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The remote work revolution: Impact on real estate values and the urban environment

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Abstract

The covid-19 pandemic induced a major shift in the prevalence of remote and hybrid work arrangements. This review article studies the effects of this remote work revolution for residential and commercial real estate values and for the future of cities. It also discusses consequences for productivity, innovation, local public finance, and the climate. The last part of the article discusses policy interventions.

KEYWORDS

house prices, local public finance, migration, office, productivity, real estate, remote work, transportation

1 | THE MACRO ENVIRONMENT

The covid pandemic heralded major changes to real estate markets. By forcing businesses to close, it forced most office employees to work from home. They stopped commuting, unclogging roads and reducing ridership in mass transit. They stopped traveling for work and business, kneecapping the hotel sector. They ordered more items online, precipitating the decline of the mall and boosting the industrial real estate sector. Covid kept seniors out of healthcare facilities and students out of dorms. Many left urban centers for the relative safety of the suburbs, where space was more abundant, or moved to warmer and more affordable cities. REIT stock prices in early 2020, shown in Figure 1, reflect the major shock that covid was, and the heterogeneous impact it had on the various real estate sectors.

The covid crisis prompted an unprecedented government response. On the monetary policy side, short-term interest rates were slashed to zero and Central Banks bought large amounts of long-term government bonds driving long-term bond yields to historically low levels. On the fiscal policy side, the federal government engaged in massive stimulus for households, businesses,

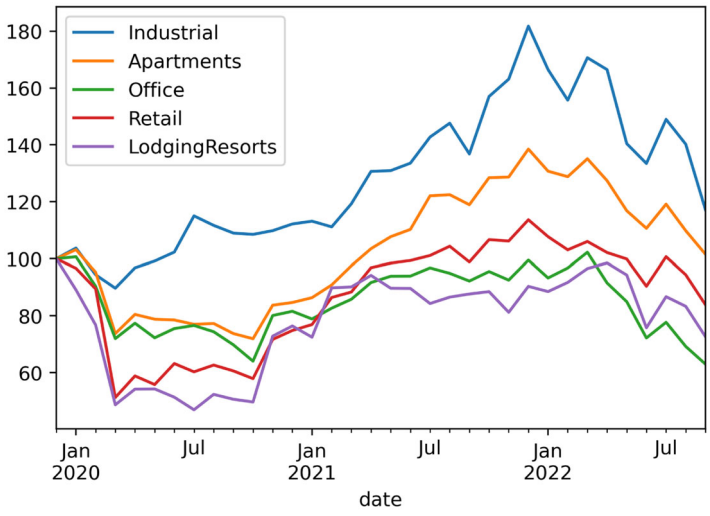


FIGURE 1 REIT returns. [Color figure can be viewed at wileyonlinelibrary.com]
Note: This figure plots national REIT sector returns from December 2019 to September 2022. Source: NAREIT.

and local governments. Real estate policy involved halting all evictions and mortgage foreclosures for nearly 2 years. The government stimulated the development of a covid vaccine. These policy interventions were successful in restoring full employment, preventing a financial crisis, as well as a foreclosure and eviction crisis. The stock market surged past its pre-covid peak. REIT returns also made a strong comeback between late 2020 and late 2021, as shown in the graph. Corporate defaults increased only modestly and came back down. Commercial real estate debt delinquencies in the CMBS market increased to 10% by June 2020 but did not cause widespread distress, and came back down to 3% by August 2022. Household and financial sector balance sheets became stronger. The U.S. house prices saw their largest year-on-year increases since record-keeping started.

However, a third phase of this covid era that began in 2022 brought new uncertainty. Inflation rates spiked to levels not seen since the 1980s and government debt levels stand at values not seen since the end of WW-II. Central Banks have begun to tighten short rates and unwind their government bond portfolios (quantitative tightening). Fiscal consolidation also seems imperative in light of the rising debt service and mounting structural deficits from social security and healthcare programs. A recession may well be around the corner. The year 2022 has already been a very challenging year for real estate, as shown in Figure 1, and the investment environment is exceptionally uncertain.

In this article, I want to focus on the longer-term implications of the pandemic for residential and commercial real estate markets, looking out beyond the current cycle. Its most long-lasting implication in my opinion is the dramatic increase in remote work.

Born out of necessity, remote work now appears to have taken hold as a permanent feature of modern labor markets. It is a benefit that employees enjoy and are willing to pay for. Their tolerance for commuting appears to be permanently reduced. Having experienced the flexibility that comes with working from home (WFH), the genie is out of the bottle. Firm managers too have come around to see its virtues, often in the form of higher productivity and profits, and have adjusted their own expectations about the number of days they expect employees to be in the office. Several firms have gone fully remote, while most others have moved to a hybrid work schedule of 2–3 days in the office. Various indicators of office demand appear to have stabilized at levels far below their prepandemic high-water marks.

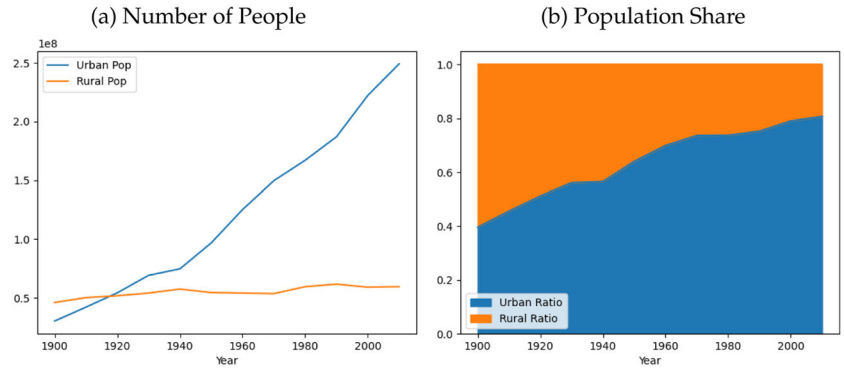


FIGURE 2 Urbanization in the United States.
[Color figure can be viewed at wileyonlinelibrary.com]
Notes: Panel (a) plots the number of people who live in urban (urban core plus suburbs) and rural areas. Panel (b) plots the share of urban population. Source: US Decennial Census.

Remote work freed up workers' choice of residence. Many households left their urban centers for the suburbs or exurbs. Some left major coastal metropolitan areas like NYC and SF for smaller metropolitan statistical areas (MSAs), often in the South and West of the United States. These migration patterns have reshaped housing markets, and at least temporarily increased suburban rents and house prices relative to urban locations.

In this article, I review what we know so far about these dramatic changes in residential and commercial real estate markets. The first section presents key facts on migration, remote work, housing markets, and office markets, in the process highlighting some new data sets that researchers have explored to track the effects of the pandemic. Then, I turn to models in finance and urban economics that study the effect of remote work on real estate markets. I raise some open questions and encourage integration of the urban and the finance approaches. The next section discusses the implications for suburban office, retail real estate, equity and debt investors, local government finances, and the environment. I finish by discussing some policy options for local government leaders.

It is my belief that academics of all stripes will be studying the remote work revolution for years to come. This topic will be particularly central for real estate and urban economists because of its profound implications for where people live, what real estate they use, transit patterns, and the environment.

The downside of writing on a topic as current as this one is that most questions are unsettled, and even the facts are still playing out and new measurement is taking place in real time. The relevant literature is growing by leaps and bounds each month, and I apologize for all relevant research that did not make it into my bibliography. Despite being premature, my hope is that this article is nevertheless a useful entry point for students interested in pushing forward the research frontier.

2 | FACTS

2.1 | Migration patterns

The world has been urbanizing for centuries. As a share of the global population, the urban areas expanded from 34% in 1960 to 56% in 2020 (Figure 2). In the United States, the urbanization rate

increased from 70% to 82.5% over this period, while in China, it skyrocketed from 19% in 1980 to 64% in 2020. The steady increase in the urban population obscures periods of rapid suburbanization such as the 1945–1970s in the United States and in Western Europe, stimulated by critical suburban infrastructure, such as a highway network. Before World War II, just 13% of Americans lived in suburbs. By 1970, suburbia was home to 37% of the U.S. population. This share grew further to 51% by 2010. That said, the number of urban dwellers grew from 64 million in 1970 to 100 million in 2010. In many ways, the 1990s, 2000s, and 2010s were a golden era for large cities (Glaeser, 2012). A virtuous cycle of improving amenities (educational and cultural institutions, entertainment, and low crime) and job opportunities attracted employers, employees, young and old, to cities. The largest cities, such as New York City, Los Angeles, and San Francisco, benefited disproportionately (Moretti, 2012). These cities became magnets for the highest-skilled employees and the top employers, with particular concentrations in finance and technology. The combination of strong demand and limited supply, resulting from geographic and especially regulatory constraints, resulted in sharp increases in rents and prices in such superstar cities (Gyourko et al., 2013; Van Nieuwerburgh & Weill, 2010). These cities became increasingly unaffordable to the average household (Favilukis et al., 2022).

The covid-19 pandemic, which hit cities like New York City early on, triggered a massive migration response. Many households fled urban centers. Most of these covid migrants moved to the suburbs of their own MSA, while fewer moved to other MSAs. This out-migration from the urban core was initially prompted by additional (perceived) risk of disease transmission, the constraints of living in a small urban apartment around the clock, closures of urban amenities (schools, restaurants, theaters, etc.), and the shift to remote work. As the pandemic went on and subsequent covid variants prompted employers to postpone return-to-work plans, the covid-induced migration patterns began to take on a more persistent character. Many households transitioned from temporarily renting a suburban home to purchasing a suburban home.

Several different data sets bear out the covid-induced migration patterns. One novel data set that is uniquely suited to study the short-run migration response is cell phone ping data. One can define a location of residence based on nighttime pings; the results are not very sensitive to how the night is defined. This allows one to track the same users over time. Gupta et al. (2022) use these data to document out- and in-migration rates between the end of February and the end of March 2020 as a function of the distance from the urban core for the 30 largest U.S. MSAs (their Figure 8). ZIP codes close to the city center experienced net out-migration rates of around 20%, while ZIP codes in the farther-out suburbs experienced net in-migration.

The larger the fraction of jobs in a ZIP code that could be done remotely, as measured by the Dingel and Neiman (2020) WFH measure, the larger the net out-migration. Those ZIP-code level population changes were positively correlated with residential rent and house price growth measures from Zillow. While the correlation with rents is stronger, the correlation with house prices suggests that housing markets may be affected for the long run.

Another new data set that has been increasingly used in urban economics settings is change of address data from Infutor, which covers about 150 million residences. Gupta et al. (2022) consider changes of address between March 1 and October 31, 2020. These data may shed additional light on the lasting nature of the relocations. The cell phone ping data likely capture both transitory and persistent moves, while the Infutor data are more likely to capture persistent relocation. These data paint the same picture: Out-migration rates are high near the urban core and low in the suburbs.

The U.S. Postal Service has also made data available that confirm this picture of out-migration from large urban population centers and in-migration into more suburban locations.Figure 3

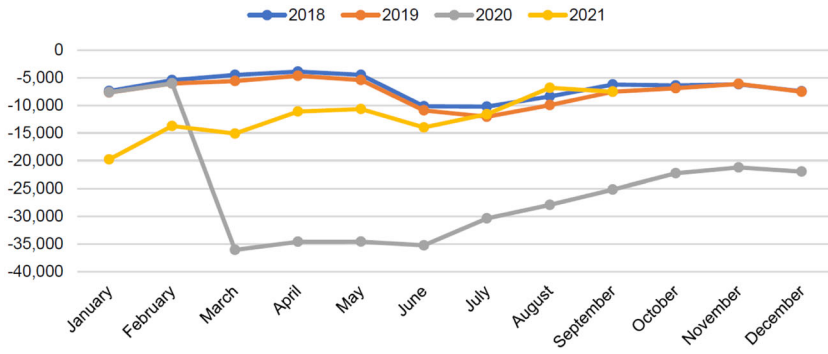


FIGURE 3 NYC net migration.
[Color figure can be viewed at wileyonlinelibrary.com]
Note: This figure plots net migration for NYC from 2019 to 2021. Source: NYC Comptroller Report.

shows net migration rates for New York City from the USPS. NYC had been losing a modest amount of population, with large out-migration exceeding large in-migration, even prior to covid. Starting in March 2020, net migration drops substantially and does not return to pre-covid levels until the Fall of 2021. Since then, NYC has been losing population at the pre-covid rate. Since March 2020, Manhattan has lost 200,000 households, the most of any county in the United States.[1] Brooklyn (–88,000) and Queens (–51,000) also appear in the bottom-10; Bronx lost 28,000.

The cities of Chicago (–75,000), San Francisco (–67,000), Los Angeles (–64,000 for the city and –136,000 for the county), Washington, DC (–33,000), Seattle (–31,500), Houston (–31,000), and Boston (–25,000) make up the rest of the bottom-10. The highest net in-migration cities are Naples, FL (+12,600), Fort Meyers, FL (+8400), Sun City, AZ (+7400), Frisco, TX (+7000), and Cape Coral, FL (+7000). The top-5 in-migration counties are Maricopa, AZ (+34,000), Lee, FL (+26,000), Riverside, CA (+23,000), Collin, TX (+22,000), and Williamson, TX (+19,000). The cumulative population patterns since the onset of the pandemic are clear: the superstar cities lost a substantial number of households, while a diffuse group of smaller cities gained population.

One concern about the U.S. Postal data is that it may not capture in-migration as well as out-migration. Data from moving companies like United Van Lines confirm the interstate migration patterns. Moving out rates for 2021 were highest for New Jersey, Illinois, New York, Connecticut, and California, all of which are high-tax, high-density locations. Moving-in rates were highest for Vermont, South Dakota, South Carolina, West Virginia, and Florida, which are low-tax, low-density states. Recent Census Bureau data also confirm these patterns. The largest 56 U.S. cities with population above 1 million lost population between July 2020 and July 2021 (–0.16%), while all other metro areas grew faster than before (+0.60%) and nonmetropolitan areas grew (+0.25%), reversing a decade of shrinkage.

2.2 | Remote work patterns

Dingel and Neiman (2020) classify occupations by whether they can be done remotely based on task descriptions. They find that about one-third of jobs in the United States can be done remotely. Combining the Dingel–Neiman teleworkability index with data from the American Community

[1] Source: https://www.arcgis.com/apps/dashboards/951428e32723456c879d0966af4baa8a

TABLE 1 WFH rate and expectation in NYC

	Attendance in PFNYC survey						WFH research
	2021-10		2022-04		2022-09		As of 2022-09
Days on-site	Reported	Exp. 2022-01	Reported	Exp. 2022-09	Reported	Exp. 2023-01	Desire
0	54%	21%	28%	14%	16%	12%	26.6%
1	8%	7%	14%	13%	11%	8%	17.0%
2	8%	15%	21%	19%	15%	15%	21.5%
3	12%	33%	17%	33%	37%	42%	8.3%
4	10%	11%	11%	12%	12%	12%	9.2%
5	8%	13%	8%	9%	9%	11%	17.3%
Average	1.4	2.3	1.9	2.4	2.5	2.7	2.1

Source: PFNYC survey and last column from https://wfhresearch.com/ https://wfhresearch.com/, conditioned on New York MSA and office-using sectors.

Survey, Delventhal and Parkhomenko (2020) calculate that 69% of college workers working in tradable-goods industries have jobs that can be done remotely, while only 19% of noncollege workers in nontradable industries can work mostly or fully from home.

Data on actual work arrangements, the uptake of remote work, remain scarce and an area that needs more research. One data source is the American Time Use Survey (ATUS) from the Bureau of Labor Statistics. It shows that, before the pandemic (2017–2019), about 5% of paid days were full days worked from home. There is a steep education gradient in uptake as well: 8.6% for people with a college degree or higher and 1.9% for people with a high school degree or less.[2] The frequency of only-WFH workdays in the ATUS had doubled between 2003 and 2019 for workers with a bachelor's degree or higher.

In the next ATUS wave in 2021, the only one in the pandemic, 38% of employed persons did some or all of their work at home on days they worked, and 68% did some or all of their work at their workplace. Note that these ATUS data do not allow one to measure how many days per week a typical employee works remotely.

In the prepandemic surveys, most workers are either full time at home or full time remote. This changes dramatically in the postpandemic period where hybrid work schedules became the norm.

The Partnership for New York City (PNYC) ran three surveys, in October 2021, April 2022, and September 2022 asking its members what share of Manhattan office workers were present in the office. As Table 1 shows, 54% of office workers were fully remote in October 2021, while only 8% of workers were in the office every workday. The average in-person days was 1.4. At that time, employers expected that number to rise to 2.3 in-person days by early 2022. The second PNYC survey in April 2022 shows that in-person days went up from 1.4 to 1.9, falling short of employers' expectations in the previous survey. The share of fully remote workers fell to 28%, but the share of workers who were in the office 4 or 5 days a week barely budged. The gains came from more workers coming to the office 1, 2, or 3 days per week. In April 2022, Manhattan employers expected further reductions in fully remote personnel by September 2022, but now expected those reductions to translate into more employees coming in the office 1, 2, or 3 days rather than 4 or 5 days. The expected average in-person days remained constant at 2.4, or slightly less than half

[2] Another data source, the 2017–2018 Leave and Job Flexibility Module of the ATUS, paints a similar picture (Davis et al., 2021). In the 2018 Survey of Income and Program Participation, 26% of college workers in tradable industries worked from home at least 1 day per week, while the uptake was only 5% for noncollege workers (Delventhal & Parkhomenko, 2020).

of the workweek. The third survey, conducted in early September 2022, found a further decline of fully remote employees to 16%. But only 9% of Manhattan office workers were in the office 5 days a week. In all, 49% of workers were in the office on a typical day. Asked about expectations regarding office presence for January 2023, employers expected only a moderate rise from 49% to 54% of employees in the office on a typical workday. NYC employers seem to believe that the return to the office has been completed and that the new normal has employees spend about half the workweek WFH.

The PNYC survey shows meaningful cross-industry variation. As of September 2022, the real estate industry has the highest in-office presence (82%), followed by law firms (61%), and financial services firms (56%). Technology firms are on the other end of the spectrum. More employees of smaller firms (fewer than 500 employees) have returned to the office on an average workday (54%) than of large firms (more than 5000 employees, 44%), but the change between April and September 2022 was stronger among large firms. As many as 77% of employers in the Manhattan survey expect that a hybrid work schedule will be the dominant form of work going forward, with only 9% requiring daily attendance.

National data on remote work uptake and policies come from a panel survey conducted by Barrero et al. (2021) monthly since May 2020. The SWAA survey does not collect data on how many days per week people work in the office, but instead ask respondents whether they currently are in-person. Across all workers, cities, and industries, 30% of paid days were remote as of September 2022. This number has been fairly stable for the prior 18 months.

Barrero et al. (2021) also ask employees and employers about their desired work schedules. The last column of Table 1 shows employees' desired work schedules for the New York MSA for office-using sectors in September 2022. They are not that far from the actual remote work experience, but still tilted toward more remote work than what was observed at that time.

In the time series, employer plans for days WFH "after the pandemic ends" for workers able to work from home have gradually increased from 1.6 in July 2020 to 2.3 days in July 2022, and are stabilizing afterward. The gap between employer plans and workers' desires for remote work has been shrinking.

Hybrid work arrangements have become important, with about 30% of full-time employees in the SWAA working some days on-site and some days at home, 15% working fully remotely, and 55% working fully on-site. For workers who are able to work from home, hybrid work dominates with a 45% share and a further 20% of workers are fully remote. These fractions have been stable since November 2021.

A different data source on remote work practices comes from job ads. Figure 4 shows the share of job postings with compensation of at least $100,000 per year that are for fully remote positions. This share has been rising fivefold over the past 3 years, and has stabilized at around 10%. Data from Indeed show that the increase in remote work postings has been highest for economists, followed by actuaries, financial developers, and software developers.

What are the factors that have impeded the return to the office in the short run? The main factor seems to be commuting time. Collectively, Americans save 60 million hours per day by not commuting. Workers who live further away are working more days remotely and have been slower to come back to the office. Safety and reliability of public transit is cited as a major issue in the PNYC survey. Finally, employees' perception of high productivity when WFH is another impediment. Health concerns seem to have abated compared to earlier surveys at the start of the pandemic. The pandemic may have driven households to the suburbs. But now that they have relocated, it is the high commuting costs that prevent them from returning to the office.

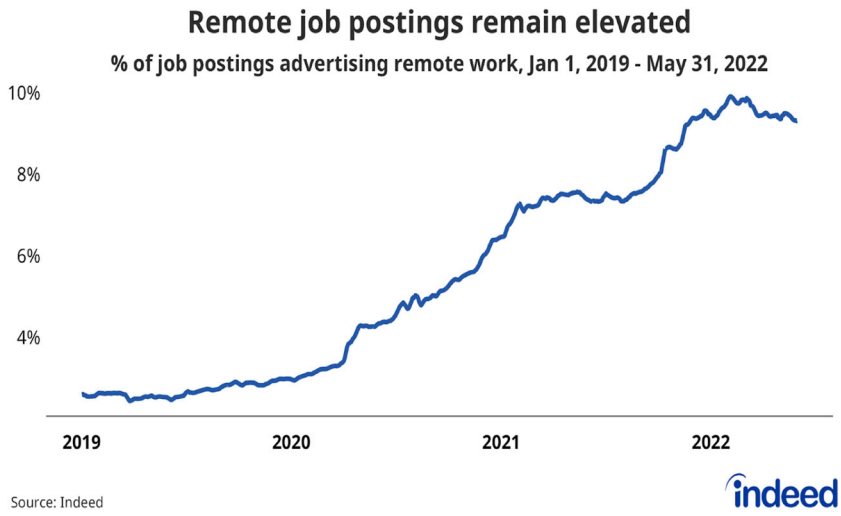


FIGURE 4 Share of remote job postings.
[Color figure can be viewed at wileyonlinelibrary.com]
Note: This figure plots remote job postings as a fraction of total job postings from January 2019 to May 2022. Source: Indeed.

With remote work having become more ingrained and having been a much better experience than expected, surveys indicate that attitudes toward remote work have shifted (Barrero et al., 2021; Brynjolfsson et al., 2020; Bartik et al., 2020; Bick et al., 2021; Ozimek, 2020; Wang & Zhou, 2022). I discuss the implications of WFH for productivity and innovation in much more detail below (section 4.5).

2.3 | Residential rents and prices

The exodus from urban centers resulted in a large increase in house prices and rents in the suburbs, with the opposite occurring in the city centers. Figure 5, taken from Gupta et al. (2022), illustrates this phenomenon for rents (left panel) and for house prices (right panel) for the New York MSA. Using Zillow's rent index and house value index data at the ZIP-code level, it plots the percentage change in rent (left) or house price (right) in each ZIP code as a function of the distance (the logarithm of 1 plus the distance) to Grand Central Terminal in Manhattan. The green line is the binscatter plot for the pre-covid period (January 2014 until December 2019). It shows similar rent growth and falling house price growth as one gets farther removed from the city center. The red line shows the rent or price gradient during the covid period. The relationship between rent growth and distance from the city center is steeply upward sloping: rents are declining sharply near the center and growing rapidly far away from the center. The same pattern holds for prices.

The urban rent and price gradient is traditionally negative: As one gets farther from the city center, commuting costs rise and access to (consumptive and productive) amenities in the city center declines, and house prices and rents fall. During covid, the urban rent and price gradients *flattened* considerably. The rent-distance elasticity turns from negative to zero between December 2019 and December 2020, after controlling for covariates, as illustrated in the left panel of Figure 6 for the 30 largest MSAs in the United States. The price-distance elasticity also increased considerably, as shown in the right panel, but the increase was smaller and the relationship between price and

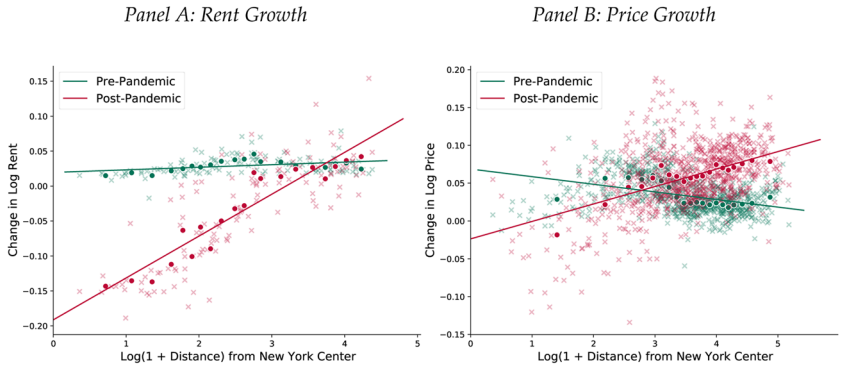


FIGURE 5 Changes in rent and price growth rates.
[Color figure can be viewed at wileyonlinelibrary.com]
Note: This figure shows the annual changes in log rents versus the same month in the prior year (panel a) and in log prices (panel b) over the prepandemic period (Jan 2014–Dec 2019) compared with the period during pandemic (Oct 2020–Dec 2020) across distance from the center of New York, measured as the log of (1 + distance to Grand Central Terminal in kilometers). Source: Gupta et al. (2022).

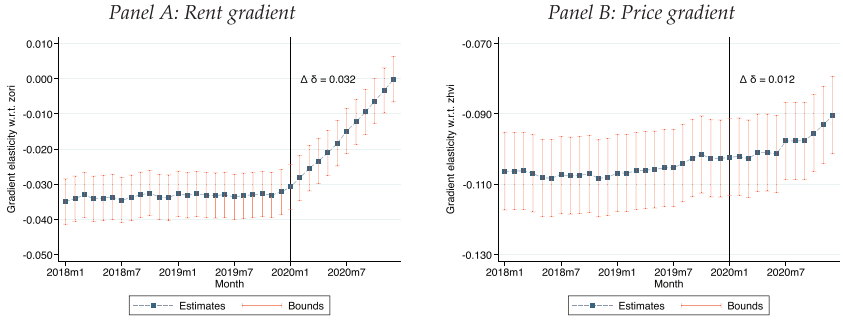


FIGURE 6 Rent and price gradients across top 30 MSAs.
[Color figure can be viewed at wileyonlinelibrary.com]
Notes: This figure shows bid-rent function slope coefficients estimated from the panel regression: $\ln p_{ijt} = \delta_t(\text{Month}_t \times [\ln(1 + D(\mathbf{z}_{ij}^z, \mathbf{z}_j^m))]) + \beta X_{ij} + \alpha_t \text{Month}_t + \alpha_j \text{MSA}_j + e_{ijt}$. The dependent variable is log rent (left panel) and log price (right panel). The graph plots δ_t, the coefficients on the interaction terms of month and distance. The sample consists of all ZIP code-month observations in the largest 30 metropolitan areas for which both price and rent data from Zillow are available. The time series is from January 2018 until December 2020. Distance is measured in kilometers between the centroid of the ZIP code and the city hall of the main city of the metropolitan area. The two panels report the change in gradient from Dec 2019 to Dec 2020 as $\Delta\delta$. The controls X_{ij} are median household income, median age of the head of household, proportion of Black households, and proportion of individuals who make over $150k, all drawn from the 2019 American Community Survey. The specification also includes month and MSA fixed effects. We draw a vertical line to define the postpandemic period, starting in January 2020. Source: Gupta et al. (2022).

distance remains firmly downward sloping. Listing prices show a similar pattern as transaction prices, as do the number of listings and housing liquidity measured by days-on-the-market.

To get at the mechanism, Gupta et al. (2022) explore the heterogeneity in the relative evolution of urban versus suburban prices and rents. They correlate the 2019–2020 change in the rent and price gradients across MSAs to the Dingel–Neiman teleworkability index, a measures of covid stringency, and an index of housing supply inelasticity at the MSA level. The covid stringency measure captures the degree to which urban amenities became inaccessible due to lockdowns.

While all three covariates enter significantly in univariate regressions, the teleworkability index drives out the other two in a multivariate regression. They conclude that the flattening of the urban price and rent gradients mostly reflects the reduction in commuting costs. Analysis at the ZIP-code rather than MSA-level corroborates these findings and enables better measurement of (at least some) urban amenities.

The effects of remote work on rents are stronger than on house prices, but present for both. Changes in rent reflect short-run changes in real estate markets. Changes in prices, however, also contain a long-run expectations component as people purchase property in anticipation of changes in future rents. This suggests that some component of WFH is expected to be temporary, reflecting particularly flexible remote working policies during 2020 which may not last forever. That said, the effect of WFH on prices is substantial and points to a persistent change in expectations about future remote work policies and commuting patterns.

The relative decline in residential rents and prices in the densest areas is confirmed in work by Ramani and Bloom (2021), Liu and Su (2021), D'Lima et al. (2022), and Althoff et al. (2020). Rosenthal et al. (2022) report a similar relationship for commercial real estate.

Gupta et al. (2022) discuss what the evidence on the relative change in urban versus suburban prices versus rents implies for expectations about future rent growth, seen through the lens of a present-value model. This evidence has different implications under a model where the changes in 2020 are purely transitory and the housing market gradually reverts back to its prepandemic state, than under a model where the changes in 2020 are permanent. The real world lies somewhere in between these two extreme cases. Evidence from a February 2021 Pulsenomics survey shows that 36% of housing-market experts viewed the shift to WFH as permanent, while 64% believed it was transitory. Using these shares as weights to average between the purely permanent and purely transitory model, Gupta et al. (2022) quantify the expected rebound in urban relative to suburban rents.

Updating the analysis in Figure 6 to October 2022, I find that the increases in the rent and price gradients continue in 2021 and 2022. Hence, the predicted relative rebound in urban rents has not yet materialized.

Another phenomenon is the evolution of house prices across MSAs. While there was much less pandemic-induced migration across MSA borders than within-MSAs, there definitely was some. Anecdotal evidence of migration toward places such as Boise, ID, Miami, and more generally smaller and less densely populated MSAs abounds. In spatial equilibrium models, and depending on the housing supply elasticity of the recipient locations, this should push up house prices. This may result in some convergence of house prices across MSAs, after decades of growing house price inequality (Brueckner et al., 2021; Gyourko et al., 2013; Hilber & Mense, 2021; Van Nieuwerburgh & Weill, 2010).

One advantage of looking at cross-sectional differences between suburban and urban locations, or even across MSAs, is that the macroeconomic environment is controlled for, differenced out. That said, the evolution of MSA or national house price levels during this period has been breathtaking. House prices grew 41.70% nationally between February 2020 and August 2022. Ultra-low mortgage rates, low risky premia, and the pandemic-induced increase in demand in the wake of a limited inventory of houses for sale all contributed to this historic house price boom (Mondragon & Wieland, 2022).

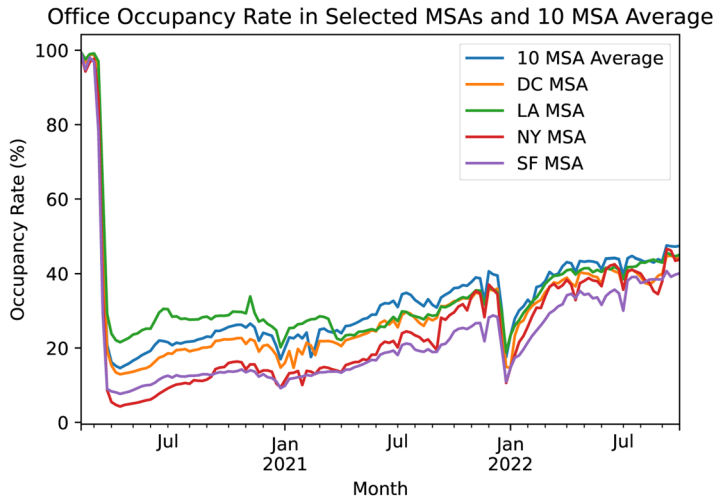


FIGURE 7 Kastle barometer for selected MSAs and 10 MSA average.
[Color figure can be viewed at wileyonlinelibrary.com]
Note: This figure plots office physical occupancy rates for DC, LA, NY, SF MSAs, and the average of 10 MSAs (the rest ones are Austin, San Jose, Houston, Dallas, Philadelphia, and Chicago).
Source: Kastle.

2.4 | Office use and rents

One metric of physical office occupancy/use comes from Kastle, which captures turnstile data at the entrance of large offices. It tracks weekly office use in 10 major U.S. cities. The time series in Figure 7 indicates a near total emptying out of offices when the pandemic first hit, followed by several episodes of recovery and relapse when the Delta and Omicron variants of the covid-19 virus emerged. Occupancy stabilizes at around 40–45% of prepandemic levels in the spring and summer of 2022. It does not show a major rebound after Labor Day 2022, just like the promised return after Labor Day did not materialize in 2020 and 2021 either. San Francisco is lagging other major markets in the return to the office. Too little is known about how representative this sample of buildings is.[3] But the data indicate an enormous drop in office use, which seems to have lasted far beyond initial expectations.

As of mid-October 2022, Kastle began reporting office occupancy for each day of the week. Across the 10 main MSAs they track, occupancy peaks on Tuesday and Wednesday at around 56% and is lowest on Fridays at 33%. This suggests that even on peak days office use remains low.

Another metric is the VTS office demand index, which is based on office broker visits. This measure of office demand stands at around 50% of its prepandemic value in July 2022, as shown in Figure 8. To the extent that broker activity is a leading indicator of leasing activity and office use, this indicator paints a similar picture of persistently depressed office demand.

Arguably, the most relevant data for office valuations come from actual leasing activity. Compstak provides such data, crowd-sources from the brokerage community, in 105 U.S. office markets. Leases are often entered by multiple brokers and cross-checked for accuracy. Data coverage ramps up during the 2000–2015 period and becomes quite comprehensive, especially in large markets, such as NYC. Figure 9 plots total annual office lease revenue on all active leases, excluding subleases, between January 2015 and May 2022. The left panel is for all 105 markets, the right panel for

[3] The sample is about 3800 office buildings in 10 metropolitan areas, and includes both central business district and suburban office. The data set does not cover office buildings owned by some of the largest New York City office owners. Those office owners did participate in the Partnership for New York City survey, which indicates similar office presence of around 50% of workers on an average day at the start of September 2022.

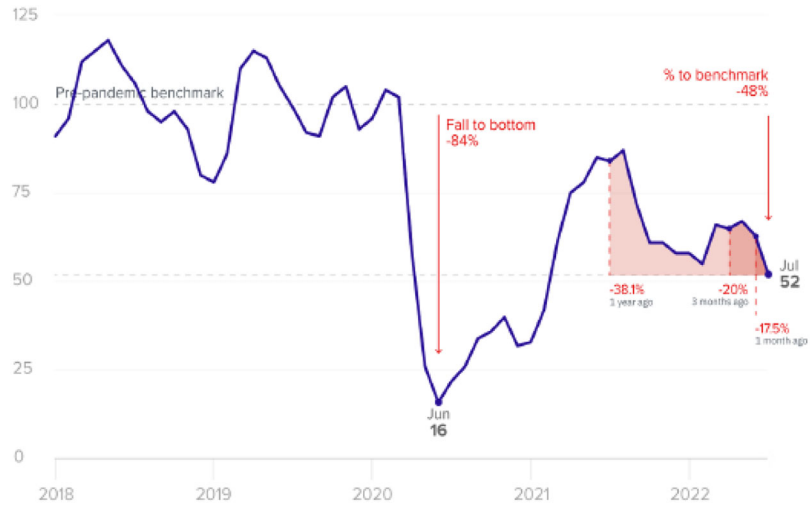
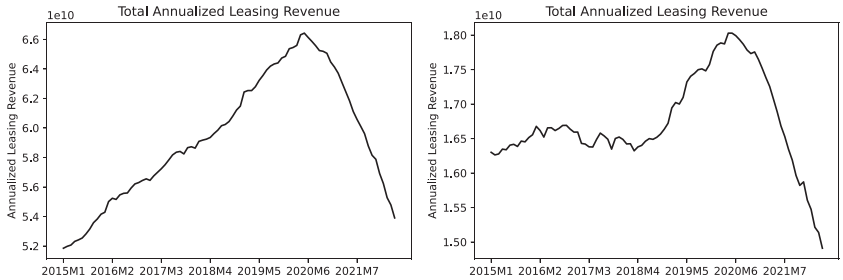


FIGURE 8 VTS office demand index.
[Color figure can be viewed at wileyonlinelibrary.com]
Source: VTS Office Demand Index Report.



(a) National (b) New York City

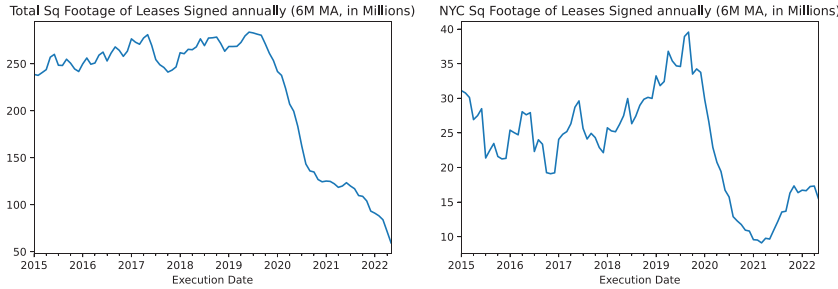
FIGURE 9 Total lease revenue on in-force contracts.

Source: Compstak, Gupta et al. (2022).

NYC. Between December 31, 2019 and May 31, 2022, lease revenue fell 17.5% in the United States and 16.5% in NYC. This is a substantial, but not yet catastrophic drop.

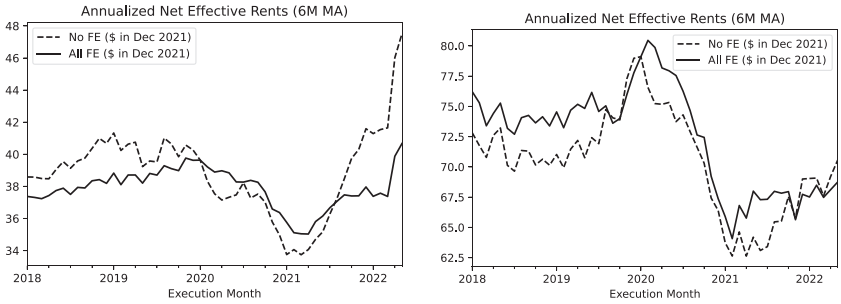
However, office leases tend to have a long maturity, about 7.5 years on average in the Compstak data set. Only 30.12% (measured by square feet) of tenants with active leases in December 2019 had to make lease renewal decisions in 2020, 2021, and the first half of 2022. That share is only 22% in NYC. Moreover, during 2020 and 2021, we see a large increase in the share of newly signed short-term leases (less than 3 years maturity) and a large decline in leases signed longer than 7 years. Tenants are kicking the can down the road and buying time amidst great uncertainty about their future office plans. Of all active leases outstanding on May 31, 2022, 26.1% of tenants (by square feet) face renewal decisions in the second half of 2022, 2023, or 2024.

Turning to newly signed leases paints a more worrying picture of the state of the office market. Figure 10 plots the amount of newly signed leases, in square feet. It is a 6-month moving average, annualized. It shows a dramatic drop from about 250 mi sqft in newly signed leases per year at the



(a) National (b) New York City

FIGURE 10 New leases signed.
[Color figure can be viewed at wileyonlinelibrary.com]
Source: Compstak, Gupta et al. (2022).



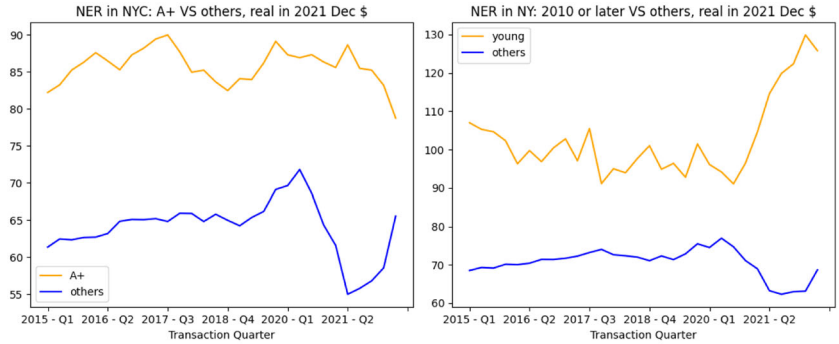
(a) National (b) New York City

FIGURE 11 Net effective rent for newly signed leases.

Notes: The figure plots the net effective rent from January 2018 to May 2022. Panel (a) is for all U.S. markets. The dashed line is the simple average across markets, while the solid line removes market fixed effects. Panel (b) is for New York City. The dashed line is the simple average across submarkets, while the solid line removes submarket fixed effects.
Source: Compstak, Gupta et al. (2022).

end of 2019 to less than 100 million sqft in the first half of 2022 nationwide. The right panel for NYC shows a similarly large decline. New leasing activity has slowed down to a level not seen in recent memory. Even when tenants sign a new lease (in the same building or in a different building), they often take less space. In other words, tenants who have had to make active space decisions have been giving up space. With more square feet of leases expiring than square feet of leases being signed (negative absorption), the contractual vacancy rate has increased substantially. It has now reached levels not seen in decades in several markets. For example, the Manhattan office vacancy rates stand at 21.9% in 2022.Q3, a sharp increase from 11.1% in 2019.Q4, and the highest level since the start of the time series in 1987. SF saw the most dramatic increase in vacancy from 5.2% in 2019.Q4 to 23.0% in 2022.Q3.

Net effective rents on new office leases reflect the rent effectively earned by the landlord after accounting for contractual rent escalations, the free rent period, and for tenant improvements. To enhance comparability over time, we deflate NERs by the consumer price index based in December 2021. The left panel of Figure 11 shows a modest decline in NERs on newly signed leases in the United States in 2020 and the first half of 2021, followed by a rebound. The rebound



(a) A+ Buildings (b) Young Buildings

FIGURE 12 Net effective rent for newly signed leases in New York City.
[Color figure can be viewed at wileyonlinelibrary.com]
Notes: The figure plots the net effective rent from January 2015 to May 2022. Panel (a) is for A+ buildings versus A-/B/C buildings in New York City, defined as in the text. Panel (b) is for young versus old buildings in New York City, where young is built after 2010. Source: Compstak, Gupta et al. (2022).

is more subdued once composition effects are removed (solid line) from the raw average (dashed line). The right panel shows the NER on newly signed leases in NYC. After removing composition effects across submarkets, NYC office rents on new leases are down by 16% in 2020. The rebound in 2021 and 2022.H1 is much more subdued and partial. Even this substantial decline may be cushioned by another composition effect: the (relatively few) new leases that are signed may be biased toward higher-quality office buildings and deeper-pocketed tenants. As vacancies continue to rise, more downward pressure on NERs is expected.

Not all office is created equally. The data provide support for a flight-to-quality narrative. Compstak ranks offices by quality: A, B, and C. Gupta et al. (2022) define A+ buildings to be those class-A buildings where at least one lease was signed in the past 10 years at an NER that was in the top-10% of NERs among all leases signed in that quarter and submarket. They find smaller reductions in lease revenues on active leases in such buildings. They also find more favorable NER dynamics on newly signed leases, as shown in the left panel of Figure 12 for NYC. The right panel plots the average NER in NYC on newly signed leases in buildings constructed after 2010, which displays a strong increase. Anecdotal evidence abounds of thriving firms moving to newer, highly amenitized, more expensive office space, but often occupying less total space than in their prior location.

3 | MODELS

A recent literature has begun to study the effects of remote work on real estate values. The first branch of this literature takes an asset pricing approach. The second branch takes an urban economics approach. Both lines of attack have much to teach us, and offer complementary insights. I will argue that, ultimately, we need to work toward a synthesis of these two branches if we want to fully understand and quantify the short- and long-run impact of remote work on real estate values and cities.

3.1 | Asset pricing models

A first approach to model the impact of remote work on office valuation is the asset pricing route. This is the approach taken by Gupta et al. (2022). As in all of asset pricing, the value of a building is the present value of its (stochastic) future cash flows, discounted at the stochastic discount factor (SDF), which reflects the systematic risk in the cash flows.

They model a building as a portfolio of long-term office leases that generate rental revenue. When a new lease is signed, the rent equals the market (net effective) rent, and the NER remains constant in nominal terms throughout the length of the lease.[4] When the lease is up for renewal, a fraction s^O of the space renews. This reflects both the extensive and the intensive margin of renewal, that is, whether or not a new contract is signed and how much floorspace is renewed conditional on renewal (up to the original size). Buildings that have vacant space lease up a share s^V of that space. Buildings also have operating expenses, capital improvements, and leasing expenses. Some expenses are variable and some are fixed in nature. The presence of fixed costs creates operational leverage in the building's net cash flow, the net operating income.

The key consideration in the asset pricing approach is the presence of aggregate risk. Gupta et al. (2022) conceptualize this as the state of the economy following a Markov chain that can take on four values. The first part of the Markov chain governs business cycle risk; fluctuations of the economy between expansions and recessions. The second part of the Markov chain governs the uncertainty associated with remote work practices. In the no-WFH state, little work is done remotely. In the WFH state, a substantial amount of work takes place at home. Thus, there are four states of the world z: no-WFH expansions (E), no-WFH recessions (R), WFH expansions (WFHE), and WFH recessions (WFHR).

The calibration of the model consists of three blocks: the 4×4 transition probability matrix that governs the state transitions $\pi(z, z')$, the 4×4 SDF matrix that governs the value of a dollar in each of the states $M(z, z')$, and the building's cash flows in each state z. Specifically, (1) the growth rate of market rents, (2) the growth rate in net new office supply (new construction minus depreciation), (3) the renewal rate s^O, (4) the vacancy fill rate s^V, (5) the variable expenses per sf, (6) the fixed expenses, (7) the leasing commissions on new leases, and (8) the leasing commissions on renewals are all allowed to differ across the four states.

Since a central advantage of the asset pricing approach is the consideration of aggregate risk, an important question is how to quantify this risk. The value of the SDF in expansions and recessions can be chosen to match the mean risk-free interest rate and stock market return in expansions and recessions, a standard approach. This leaves the question how to quantify "WFH risk," the novel risk associated with transitions from the no-WFH to the WFH state. The SDF in the WFH state relative to the no-WFH state is chosen to allow the model to match the expected return on a WFH equity factor. Gupta et al. (2022) construct a stock portfolio that goes long publicly traded companies that benefit from remote work (e.g., Zoom) and short companies that benefit from in-person interactions (e.g., airlines). Real estate companies are excluded from this WFH equity factor construction on purpose. However, the cross-section of office REITs traded in the United States can be used to estimate the market price of risk associated with WFH risk. This approach reveals that equity markets consider the WFH state to be an adverse state of the world, with a high value for the SDF. Cash flows in a future WFH state have a low present discounted value.

A second central question is how likely the economy is to remain in the WFH state once it has transitioned from the no-WFH into the WFH state. In other words, what is the persistence

[4] Recall that the NER already reflects the rent escalations built into the typical office lease.

of the remote work state. Given that the economy has only been in the WFH state for about 2.5 years at this point, there are not enough data from actual remote work experiences to pin down this key parameter. We use forward-looking asset prices, in particular, publicly traded office REIT stock prices, to infer this persistence parameter. Specifically, given the SDF and the cash flow parameters, we ask what persistence parameter can justify the return on office-centric REITS in the year 2020. We take into account that REITS typically own the highest quality offices, the A+ segment. The answer we get is an annual persistence of about 0.82. This parameter implies that, if the world was in the WFH state in 2021, there is a 20% probability that it will remain in the state until 2029. Conversely, there are a lot of future paths in which the economy transitions back to the no-WFH state; a return to the office. It is this *WFH risk* that is central to the question of office valuation.

The third block of the calibration are the cash flow parameters. Those are chosen to match market rent dynamics, supply growth, and occupancy rates over the business cycle. The model is calibrated to deliver the observed declines in office occupancy rates, NER, and active leasing revenue in the period 2019–2021.

The main calibration is done for the New York city office market, the largest office market in the United States, but the approach is generic and can easily be applied to other markets (the authors also provide calibrations for San Francisco and Austin) or to other types of real estate (e.g., retail). There is one calibration to the entire NYC office stock and a separate one for the A+ segment, defined as buildings fetching rents in the top-10% of the rent distribution. The A+ segment has different cash flow parameters, calibrated to the A+ segment of the data.

With these parameters in hand, Gupta et al. (2022) compute the value of the NYC office stock in each state of the world.[5] They then simulate the evolution of office values as the economy transitions from a no-WFH expansion in 2019 to a WFH recession in 2020 to a WFH expansion in 2021. After 2021, the economy evolves stochastically according to its laws of motion. This uncertain future includes many paths where the economy returns to in-person work as the dominant form of work, and some paths where remote work persists for a long time. These simulations, shown in the left panel of Figure 13, reveal that the entire NYC office stock falls in value by 44.80% in 2020. Ten years after the transition, office values remain at levels that are 39.18% below the valuation in 2019 along the average path. Conditioning on remaining in the WFH state for at least 10 years (red line), office valuation is 59.86% lower in 2029 than in 2019.

This same simulation produces a decline of 27.13% for the A+ office sector, shown in the right panel of Figure 13. The mean path has office values down by 20.67% in 2029 compared to 2019. In the scenario where the economy remains in the WFH state until at least 2029, the decline in A+ office values is 35.28%. The better performance relative to the All Office stock is due to the stronger rent growth for A+ in the WFH states, as well as a lower risk premium for A+ office especially in the WFH state. The relatively strong performance of A+ reflects the relative safety of A+ office. On the other side of the quality spectrum, the performance of A-/B/C-class office is strictly worse than that of the overall market. Its 2020 value decline is –68.98% compared to –44.80% for all office. These numbers imply that class B/C office may have become a stranded asset. For the United States as a whole, the authors estimate a $414 billion loss in office value.

[5] The model has the exogenous state, which takes on the four values described above, and two endogenous state variables: the occupancy rate and the rent on in-force leases relative to the market rent. The value of the NYC office stock is the expected present discounted value of the future leasing revenues, obtained by solving a first Bellman equation, minus the expected present discounted value of the future expenses, obtained by solving a second Bellman equation.

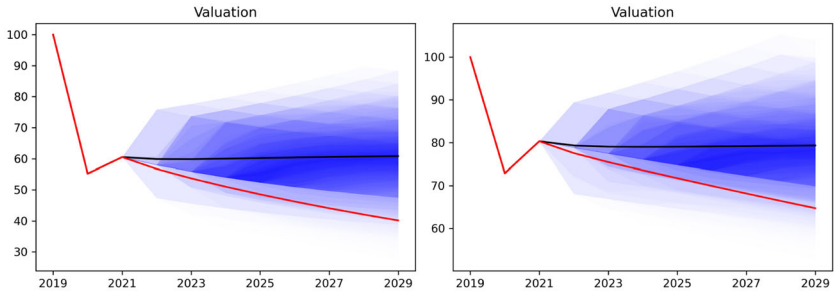


FIGURE 13 Office values in the age of remote work.
[Color figure can be viewed at wileyonlinelibrary.com]
Notes: The graph shows the evolution of the office value V for a transition from expansion in 2019 to WFH-R in 2020 and WFH-E in 2021. From 2022 onward, the state evolves stochastically. The shaded areas show percentiles of the distribution of simulated paths, with the darkest color indicating the 40–60 percentile range, and the lightest color the 10–90 percentile range. The left panel is for the entire New York City office market, while the right panel is for the A+ segment. Source: Compstak, Gupta et al. (2022).

Below, I discuss the implications of such large value declines to investors in equity and debt tied to office real estate. It also looks at the implications for other real estate, such as urban retail, and for municipal finances.

One natural policy response is to upgrade class A-/B/C office to class A+ office to attract the discerning tenant who desires the highly amenitized office space. For many office buildings, such upgrades are the easiest and sometimes only possible "conversion strategies." I discuss office-to-apartment (OTA) conversion in the policy section below. Indeed, the Compstak data on *tenant improvements* (TI) indicate that office landlords are spending record amounts on upgrading and redesigning their office space. This includes more meeting and social space, more amenities (gym, pet care, child care, and restaurants), and fewer individual work stations and offices (which can be shared since not every worker who needs an office is in on the same day). While the asking rents may be high upon completion of the A+ space, net effective rents (which include TI) may be much less impressive. Even though the return on investment for the renovation may be low, the landlord's alternative of doing nothing may condemn her to higher vacancy and even lower rent revenue. In addition, the general equilibrium effects of such conversion strategy are unclear. Hypothetically, if all A-/B/C office space became A+, supply would exceed demand (tenants able to pay A+ rents) and A+ rents would need to fall to clear the market. Rents and return-on-investment from renovation are even lower in general than in partial equilibrium. Quantifying this is an interesting direction for research.

3.2 | Urban models

The second approach studies the impact of remote work in traditional models of urban economics. In contrast with the asset pricing approach, these models have no risk and are static. However, they can allow for space use in flexible ways and can be calibrated to many locations. They are useful for understanding the new long-run internal structure of cities after the transitory disruptions from remote work have been fully played out. This fast-growing branch of the literature features

both simple models that admit closed-form solutions and richer quantitative models amenable to policy analysis.

Kyriakopoulou and Picard (2022) study how remote work affects land prices and wages in a stylized spatial equilibrium model of a closed city where firms and households choose where to locate relative to the city center (CBD). WFH affects commuting costs, residential housing demand–via the need for a home office,– and firm productivity. More WFH has two opposing effects on firm productivity. It creates fewer agglomeration benefits resulting from fewer in-person interactions between employees of different firms, but more agglomeration benefits from interactions among managers which become easier when the CBD shrinks. WFH makes it easier to sustain a monocentric city where all work takes place in the city center and all residents live outside the center. Office rents and residential rents fall in the amount of remote work, except at the fringes of the city, an area in which the city newly expands after WFH. The net effect of WFH on household welfare and aggregate productivity is ambiguous. It depends on city size, on how productive WFH is relative to working in the office, on the size of commuting costs, and on the size of the home office. Since firms do not internalize the agglomeration benefits they generate by being in-person, the privately optimal amount of remote work is larger than the socially optimal amount.

Brueckner et al. (2021) study the spatial equilibrium across cities in a world with fully remote work. When location of workplace and residence are fully separated, the standard spatial equilibrium conditions change dramatically. When cities differ only by productivity, workers move to cheap, low-productivity places and telecommute to their original jobs. When cities only differ by amenities, workers move to high-amenity cities and keep their jobs in low-amenity locations. Wage variation disappears as an equalizing force, and house prices do all the adjustment to make sure that all cities are equally attractive to all households. The model predicts increases in rents and prices in high-amenity, low-productivity cities and decreases in low-amenity, high-productivity cities.

Delventhal & Parkhomenko (2020) [DP22] and Davis et al. (2021) [DGG22] study richer models featuring worker heterogeneity and more locations. They are both fascinating and rigorous papers that can help us understand the quantitative implications of remote work for productivity, labor supply and demand, wages, the allocation of land between office and residential space, office and residential rents, income and consumption inequality, and ultimately welfare. To appreciate their findings, it is worthwhile digging into the assumptions, results, and mechanisms. Other papers in this vein are Behrens et al. (2021); Gokan et al. (2022).

DP22

The model features high-skilled (college-educated) and low-skilled (noncollege-educated) workers in telecommutable and nontelecommutable occupations, working for firms in the tradable and nontradable sectors. Workers choose their industry of employment, where to live, where to work, and how to split disposable income between tradable goods, nontradables, and housing. Workers in telecommutable occupations also choose how much time to work from home versus in the office. Workers dislike commuting because, on days they go in, it takes time and creates extra disutility. The preference for remote work differs by skill level and industry. This distaste

for commuting is the key parameter that changes over the course of the pandemic.[6,7] Remote and on-site work are complements, following the production function estimated by DGG22, so that workers prefer to split their time between WFH and working on-site. The productivity of remote work differs by skill level and industry.

Firms produce combining labor and real estate. They hire workers of different skill levels, working both on-site and remotely. There is an endogenous component to productivity which captures agglomeration effects: Productivity is higher in locations with more employment density. Remote work contributes less to the agglomeration benefits than on-site work.

In each location, the existing floorspace is split between office and residential use, where the latter includes extra space for a home office. More floorspace can be produced with land and tradables, given a location-specific supply elasticity, and can only be used in the location it is built. Residential amenities have an exogenous component and an endogenous component that depends on residential density. Landlords are inside the model, sell all available land, and consume the proceeds of land sales on tradables.

In a competitive labor market, workers get paid their effective output per hour times the wage minus the cost of office rent and housing rent. The optimal amount of WFH trades off the relative productivity of WFH versus on-site, the relative cost of floorspace in the location of work versus home, and the commuting costs.

The calibration has 4500 locations. It matches prepandemic population shares, sector-education-location employment shares and wages, as well as commuting frequency and time between each pair of locations. It also matches prepandemic facts on telecommuting uptake and frequency by education and industry, as well as relative wages and distances to work sites of telecommuters.

The calibration indicates that college workers in tradable sectors are about 12.5% more productive WFH than on-site, and noncollege, nontradable workers are about 2.5% less production WFH than on-site. This evidence is broadly consistent with the survey evidence on productivity I discuss below.

The calibration uncovers a substantial distaste for WFH, which is needed to justify the low prepandemic uptake of remote work. The main counterfactual lowers the aversion to WFH in order to match the observed increase in the uptake of telecommuting for each group before versus after the pandemic (as indicated by employers in the Barrero et al. (2021) survey). The required reductions in WFH aversion are larger for the high-skilled, but the post reduction levels are still higher for high- than for low-skilled workers. The latter possibly captures stronger networking or career benefits from being in the office for the high-skilled.

After the WFH aversion *preference shock*, people who can telecommute relocate away from denser to less dense areas. But they spend less time commuting overall since they spend more time WFH. The high-skilled in telecommutable jobs spend nearly 3 more days per week working remotely. People who cannot telecommute take advantage of the lower house prices in city centers to relocate closer to better-paying jobs.

Total employment is unchanged in the largest population centers, falls in the next tier of locations by population, and rises in the least-dense areas. The rise in employment in small locations

[6] This preference parameter could be interpreted more broadly to capture career concerns associated with not going into the office.

[7] Workers also experience a separate utility penalty for living far from their work location which is unrelated to commuting costs, a feature the model needs to match the empirical relationship between telecommuting and distance to work. This feature is common to all workers and stays constant before and after WFH.

is concentrated in nontradables; service sector jobs follow the new residents. Tradable sector job growth takes place in both the least productive (smallest) cities, where real estate is cheap, and in the most productive (largest) locations, where real estate costs fall the most. The tradable sector shrinks in medium-size locations. Applied to the New York MSA, the model predicts 0.5% population growth and 1.7% job growth. Manhattan gains a lot of telecommutable jobs in the tradable sector.

The cross-sectional pattern in real estate price changes in the model is consistent with the data; there is a flattening of the urban rent-gradient curve as in Gupta et al. (2022). However, remote work has little effect on the average real estate price in the model. In the long run, space use (quantities) adjusts and prices return to prepandemic levels.

Finally, the model has interesting implications for aggregate income and income inequality. Since the high-skilled have higher productivity WFH than working on-site, the shift to more remote work increases productivity and income for the high-skilled that can telecommute. Aggregate productivity increases. The high-skill wage premium rises, but only for those who can telecommute, increasing income inequality across skill levels and WFH abilities. Spatial inequality across locations of residence falls since job opportunities in superstar cities are increasingly available to those who do not live there.

Aggregate welfare from WFH goes up by 5.2%, with gains coming from reduced commuting, better amenities, and higher consumption for those who telecommute. Telecommuters gain, while the rest of the population loses.

This article contains a useful decomposition of these welfare effects by splitting up the experiment into a sequence of steps. This sequencing conceptualizes a notion of short-run and long-run effects (even though the model remains static). DP22 imagine that the WFH aversion preference shock occurs and that, initially, nobody can move and floorspace cannot adjust. Telecommuters gain because of reduced commuting. In a second step, workers can choose new locations of residence and employment, but floorspace does not adjust. This allows nontelecommutable workers to relocate to locations left behind by remote workers, move closer to their job, and increase their income. Since the allocation of floorspace is fixed, this counterfactual can distinguish between residential and commercial (office) price changes. The former increases sharply (+16%), while the latter falls sharply (–16.5%). This is consistent with the recent boom in aggregate house prices, discussed in Mondragon and Wieland (2022) and the drop in office valuations discussed by Gupta et al. (2022). In a third step, floorspace is allowed to adjust. This can be thought of as a long-run supply response achieved through depreciation and conversion from commercial to residential, which I discuss further below. More real estate gets added to less dense locations allowing more people to move there. The CBD shrinks and with it the amount of space used for office. This long-run supply adjustment greatly moderates real estate price changes (to only +1.3% on average). The increased demand for residential and home office space takes place in cheaper and more elastic locations. Fourth, residential amenities adjust and follow workers to more remote locations, increasing workers' average distance to work. The final step switches on the effect of more WFH on reduced agglomeration economies. This effect lowers the average income gains by 1.7% points and the average welfare gains by 1.5% points.

All these results were for a model where remote work does not contribute at all to production agglomeration effects. If remote work contributes as much to the agglomeration effects as on-site work, maybe because of the advent of better remote-work technology, the welfare effects from WFH increase from 5.2% to 6.8%, with gains across the board.

DGG22

Davis et al. (2021) provide a similarly rich quantitative model. They also have two skill types and both telecommutable and nontelecommutable occupations. They also allow for two types of firms: those which allow WFH and those that do not. Workers in telecommutable occupations can choose for what type of firm to work, and how many days per week to work from home versus on-site if they work for a company that allows remote work. They model work done at home and work done in the office as complementary inputs in production and estimate an elasticity of substitution of 3.6 between on-site and remote work. This value implies that people are most productive if they do some work at home (either busy work or cognitively taxing work) and some work in the office (meetings, collaborative work, client meetings, etc.). Wages depend on days worked remotely, days worked at home, as well as on home office space and business expenditures incurred by the worker to enable remote work. There are agglomeration economies when more high-skilled work is done on-site. There is also an important adoption externality associated with remote work: the productivity of remote work increases in the aggregate amount of remote work done in the previous period.

The model has two locations: a city center and a suburban area, akin to the spatial setup in Favilukis and Van Nieuwerburgh (2021). The calibration matches moments for the average large U.S. city (the average of 21 large monocentric cities). The spatial dimension is, therefore, less rich than in DP22, which somewhat limits the model's ability to consider cross-city migration of jobs and people. The model becomes a closed-city model with a CBD, a residential zone close to the city center (zone 1), and a residential zone farther from the city center (zone 2).

DGG22 engineers the remote work revolution as a *technology shock* which increases the productivity of WFH, rather than as a preference shock (WFH aversion) as in DP22. The size of the technology shock to remote work (pre- vs. post-2020) is chosen to generate a fourfold increase in the share of full days of WFH in the model so as to match the increase in the data. The adoption externality mechanism is an important force that lends persistence to WFH. The calibration requires a 48% WFH productivity increase for low-skill and a 88% WFH productivity increase for high-skill workers.[8] This productivity shock increases wages, especially for the high-skilled with telecommutable jobs. The latter workers' income goes up by 30% in the model.[9]

The article considers a similar short-run versus long-run analysis. In the short-run, the supply of office and residential space is fixed but people can move. By moving, they change the demand for space. The model predicts reduced demand for office, a 7% decline in office rents, and an increase in housing rents due to increased demand for home office space. Home office space quadruples relative to prepandemic levels. Residential rents in the suburbs rise by more (+28%) than rents closer to the center (+17%).

The model has interesting implications for labor supply. Both high- and low-skilled labor supply increase due to the higher productivity of WFH and the fixed amount of leisure.[10] Remote days increase fourfold by virtue of the calibration, and rise to 2 days per week for the high-skilled and 1 day per week for the low-skilled. A much larger share of workers chooses to work for firms that allow remote work. In response to higher wages post-covid, the model can explain substantial

[8] The size of the WFH productivity increase depends on the magnitude of the elasticity of substitution between remote and on-site work. The more substitutable these two modes of work are, the smaller the required increase in WFH productivity.

[9] In a counterfactual exercise without productivity increase, low-skilled workers in telecommutable occupations dislike working remotely. This is inconsistent with the experimental evidence in Mas and Pallais (2017) and He et al. (2021).

[10] The fixed amount of leisure follows from preferences that are separable in leisure. This specification makes leisure independent of wages.

job switching toward firms that allow WFH even if wages at those firms are (slightly) lower. The relative increase in productivity between the high- and low-skilled creates a relative increase in wages, thereby increasing income inequality.

Spatially, there is a modest increase in the share of high-skilled workers living in the suburbs; the opposite is true for the low-skilled. There is a small loss in agglomeration benefits from having fewer high-skilled working on-site, but this negative wage effect gets swamped by the productivity gains from working remotely. Reduced agglomeration benefits reinforce WFH adoption.

The rise in consumption in equality is smaller than the rise in income inequality since work from home comes with additional business and home office expenditures.

In the long-run, the supply of space adjusts. Office space falls by 11%, home office space increases, thereby increasing the productivity of remote work further. The suburbs expand. The increase in residential space results in the return of rent levels to their prepandemic levels in the long-run (by assumption). This is directionally consistent with the prediction of Gupta et al. (2022) of a relative urban rent revival relative to suburban rents. The model assumes perfectly elastic housing supply in the long-run, which might understate the long-run impact of remote work on residential prices.

In DGG22, the WFH shock increases aggregate welfare. Welfare increases for every household type, but more so for the high-skilled who work for telecommutable firms.

The debate

DP22 rerun (their version) of the DGG22 experiment where the WFH shock is a technology shock rather than a preference shock. Accounting for the observed telecommuting frequency requires a large increase in the relative productivity of remote work relative to on-site work, on the order of 70% for high-skill and 200% for low-skill workers. These are larger productivity increases than in the DGG22 calibration. In the DP22 model, such productivity increases lead to wage increases of the same size as the productivity increases. DP22 argue that such large wage increases are counterfactual.[11] They also show that the observed mobility rates between any two locations are less strongly correlated with the model-predicted mobility rates in the model where remote work comes from a technology shock than in the model where it comes from a preference shock. In DGG22, the wage increases are at most 30% for the high-skilled in telecommutable jobs, less than 10% for low-skilled in telecommutable jobs, and lower still for those in nontelecommutable jobs.[12] Since the models are not nested, it seems important for the literature to sort out whether it is the many locations in DP22 that drive the differences in these results, or rather functional form assumptions on productivity or commuting costs that differ across DGG22 and DP22.

Any preference shock explanation faces the challenge that we had at least some experience with remote work prior to covid, and, yes, that plenty of people already hated their commute prior to covid. I think workers and firms collectively learned that mass adoption of remote work was a lot less detrimental to productivity than first feared. More on this below.

[11] The elasticity of substitution between remote and on-site work is around 4 in both papers, but there are large differences in the initial relative productivity of remote work. The latter is around 0.35 in DGG22, while DP22 calibrate it closer to 1. The impact that increasing the productivity of on-site work has on TFP—and hence on wages—is small when the initial productivity of on-site work is low. An unproductive factor will be allocated only a small proportion of the budget, so that its weight in determining overall TFP is small. The low initial productivity of on-site work likely accounts for the much smaller wage increase in DGG22.

[12] The increase in wages is muted by the complementarity of on-site and remote work. An increase in WFH productivity does not result in corner solutions for remote work days, because of the complementarity, and hence leads to more moderate overall labor productivity increases and wage increases.

To help us understand the long-run impact of remote work on real estate demand and valuations, it is important to understand what impact WFH has on aggregate productivity. While in both papers aggregate productivity increases with WFH, the extent to which it does depends on whether the WFH shock was a positive productivity shock or a preference shock, or how much of each. The answer will affect our assessment of the effectiveness of policies, such as subsidies to office-to-residential conversions, discussed in the policy section below.

Another interesting direction of exploration is to compare the predictions of these urban models for wages and earnings to the data. Liu and Su (2022) show that wages rise everywhere during the pandemic but more so in smaller than in larger population centers. The wage gradient flattens; the urban wage premium falls. This decline in the urban wage premium could reflect either higher supply of urban workers due to telecommuting or lower demand due to the loss of agglomeration benefits. The article shows that the effect on wages is concentrated among jobs with higher teleworkability scores, and that employment falls by more in larger than in smaller cities among occupations with higher teleworkability score. There is also evidence that the urban wage premium for relationship-related skills has fallen. Liu and Su (2022) interpret the evidence as consistent with weakened agglomeration economies from WFH. The models of DGG22 and DP22 produce lower agglomeration benefits, but both models emphasize strong aggregate productivity gains from WFH as well. The changes in wages and employment by skill type and telecommutability should be informative for a further refinement of the calibration of the urban quantitative models, especially the agglomeration economies. It is not inconceivable that the nature of agglomeration benefits has changed over the past few years. The parameters in the agglomeration function could have shifted or the contribution of remote work hours to the agglomeration benefits may have changed, in part due to improved remote work technologies. We have seen that these are important features that drive the aggregate welfare effects of remote work.

3.3 | Toward an urban finance synthesis

A comparison of the finance and the urban approach reveals strengths and weaknesses to each approach.

The strength of the finance approach is that it explicitly considers risk, including the fundamental uncertainty we face about the future of work arrangements. When investors are risk averse, this risk gets priced into the value of office buildings. Considerations of risk let us quantify possible scenarios for the future of remote work and the real estate values associated with each scenario. This seems particularly important over short- and medium-run horizons of, say, the next decade. The downside is that these models take the relationship between remote work and real estate cash flows as given. While they capture the stochastic nature of each, they do not endogenize that relationship. This makes it difficult to study policy counterfactuals that change that relationship, such as policies that effect the long-run use of space.

The strength of the urban models is that they allow us to think through how remote work will change the long-run use of urban versus residential real estate. Their weakness is that the models are typically static and, more importantly, do not consider aggregate risk. They often have absentee landlords. In such models, the wealth effects from the large-scale destruction of office values due to remote work are irrelevant. This compromises policy analysis, especially over shorter horizons, since who wins and loses from the policy is closely connected to asset ownership. The absence of aggregate risk also makes it difficult to match the observed valuation changes in real estate prices, which are driven to a substantial extent by discount rate fluctuations (Campbell et al.,

2009). Indeed, the urban models of DP22 and the GGG22 imply a much smaller valuation impact on office than the finance model of Gupta et al. (2022).

The literature should work toward integrating these two approaches. The paper by Favilukis et al. (2022) provides an example of this "urban-finance synthesis." It studies affordable housing policies in a model where there are two cities, with migration between them, and one of the cities has an internal city structure (an urban and suburban zone). Households are risk averse and face risk; agents inside the model own the real estate whose value gets impacted by the affordable housing policies. A similar framework could be used to study WFH, importing many of the useful functional forms and tools that the aforementioned urban literature has brought to the table.

4 | IMPLICATIONS OF REMOTE WORK BEYOND URBAN OFFICE AND RESIDENTIAL

I start by discussing implications of increased adoption of remote work on real estate sectors beyond CBD office. I then discuss implications for investors. Next, I zoom out to the local government. I discuss implications for productivity and innovation, and how real estate data can be used to infer the effects of remote work. Finally, I briefly touch upon the implications of WFH for climate change.

4.1 | Implications for suburban office

Many office workers who live in the suburbs faced a reduced burden of commuting to the CBD over the past two and a half years. They indicate in surveys that the time spent commuting is the most important factor impeding their return to the office. They also report enjoying WFH, and being willing to take a paycut for the ability to work from home 2–3 days per week (Aksoy et al., 2022; Barrero et al., 2021).

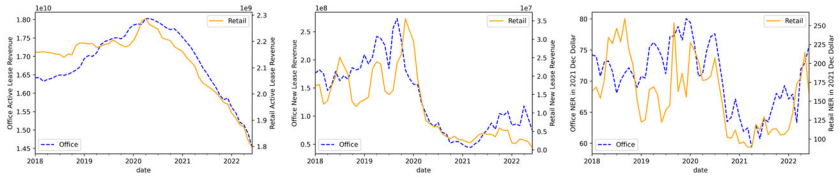
If the tolerance for commuting has permanently fallen, as in the DP22 paper, it may make sense for firms to set up satellite offices closer to where workers are located. For large firms with employees in dispersed locations, now so even more than before covid, such hub-and-spoke model may make sense. Similarly, co-working spaces could spring up in the suburbs to accommodate the distributed workforce of smaller companies. Rolheiser et al. (2022) find that high-quality suburban office prices performed much better than urban commercial real estate properties.

That does not mean that the existing suburban office stock is suitable for the needs of such office tenants. But, subject to (re-)development, the suburban office asset class may have improved prospects in the world of remote and hybrid work.

4.2 | Implications for retail and industrial real estate

The missing office workers in downtown areas have decimated urban retail. Employment in the NYC restaurant sector was down 25% from the end of 2019 to the end of 2021, or 78,000 workers (Comptroller Office). Data from OpenTable show that restaurant visits are still down 37% in NYC and 41% in San Francisco in August 2022 compared to prepandemic levels.

While the data coverage is smaller, Compstak also has leasing data for the retail sector. Figure 14 panel (a) shows total revenue from all active leases in New York City (annualized). Panel (b) shows



(a) Active Lease Revenue (b) New Lease Revenue (c) NER

FIGURE 14 Retail leasing activity in New York City.
[Color figure can be viewed at wileyonlinelibrary.com]
Source: Compstak, Gupta et al. (2022).

revenue from leases newly signed over the past 3 months (annualized). Panel (c) shows net effective rents. The solid line is for the retail sector. On all three metrics, the retail sector tracks the office sector (dashed line) closely. The graph makes clear that the urban retail sector is hit as hard as the urban office sector. One mechanism through which the shock to the office sector spills over the retail sector is through nonwork transit trips (Miyauchi et al. (2022)). When people do not commute to the office, they need to spend a longer time traveling to consume nontraded services provided by urban retailers.

Retail may relocate to where the people have moved, with shopping and entertainment activities shifting from the urban core to the suburbs. This has the potential to give new oxygen to struggling suburban malls.

This urban–suburban retail divergence plays out against the macro background of rising penetration of online shopping, a habit dramatically accelerated during the pandemic. E-commerce sales grew by 32% in 2020 and 15% in 2021, to account for 11.8% of retail sales in 2021 (Census). Excluding restaurants increases 2021 e-commerce penetration to 13.2%; also excluding motor vehicles, parts dealers and gas, that figure jumps to 17.2%.

The meteoric rise in e-commerce has been a boon to industrial real estate: warehouses, cold storage, distribution centers, and so on. Industrial was the strongest-performing real estate sector in the 5 years leading up to September 2022 (recall Figure 1). Strong rent growth in industrial supported large valuation gains and attracted new development. However, the higher interest rates and inflation in 2022 have hit industrial particularly hard since it is the longest-duration asset class in real estate.

4.3 | Implications for investors

Public equity

Equity investors in office REITs have seen stock prices plummet. Figure 15 plots the market capitalization weighted cumulative stock return from December 31, 2019 until September 30, 2022 for three NYC-centric office REITS: Vornado, SL Green, and Empire State Realty Trust. It also plots in the national office REIT return from NAREIT.[13] This evidence from the equity markets, and in particular, the persistence of the shock–equity markets are forward looking after all–is consistent with the asset pricing model discussed above. Clearly, such large and persistent losses have impacted individual and institutional investors in the equity of publicly listed office companies.

[13] The latter includes companies like Alexandria that have substantial investments in life science assets, which performed very well during the covid crisis.

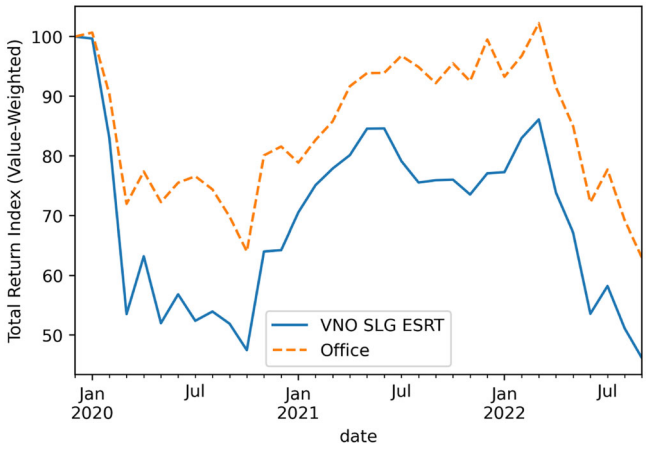


FIGURE 15 Office REITs returns during pandemic.
[Color figure can be viewed at wileyonlinelibrary.com]
Source: NAREIT and Compustat.

Private equity

But most of the office stock is not publicly listed. There has been little trade in office buildings over the past 3 years. The bid-ask spread is wide: the prices at which buyers are willing to buy office are much lower than the prices at which owners are willing to sell. Sharply declining sales volumes may be a harbinger of declining prices, a lead-lag relationship that has been observed for residential markets by DeFusco et al. (2022). Equally importantly, the few assets that trade are nonrepresentative. The search-theoretic framework of Sagi (2021) is useful for interpreting this phenomenon: the trades we see occur when a seller happens to meets a buyer with an unusually high valuation.

In the absence of trade (or the presence of advantageously selected trade), investors in privately held office assets can pretend that the assets have not lost value. This applies equally to private equity funds invested in office assets. Some have argued that the slow mark-to-marking of such funds is a feature rather than a bug. Asness et al. (2013); Gupta and Van Nieuwerburgh (2021); Riddiough (2022) suggest that investors may be willing to pay for this feature, in the form of an *illiquidity premium*.

At the core of this debate is two opposing views of the stock market. One camp sees the stock market as omniscient: all available information is rapidly and efficiently impounded into stock prices through trading. Under this view, the decline in office REIT prices proves that remote work will result in lasting reductions in office demand and lower valuations for office assets. REIT prices are a leading indicator of privately held office values. The other camp believes that stock markets are noisy; prone to irrational mood swings by investors with behavioral biases. The rise of passive investing over the past decade (e.g., REIT ETFs) has made it even easier to invest in stocks for uninformed investors. Stock prices reflect the ignorance rather than the wisdom of the crowd. Private markets are where the experts with domain knowledge trade.

The forces of arbitrage should drive the valuations of public and private assets toward each other. If the stock market is wrong in assigning such low office valuations, a large private equity fund should just take a publicly traded office REIT private, sell its assets in the private market, and make a profit. In real estate, this process is slow and subject to substantial transaction costs. But the logic still applies. Price/NAV ratios in the office sector are historically low. Green Street reports a 47.2% discount of REIT valuations to net asset value as of August 19, 2022 for the 16 office REITs in the United States. The premium to asset values, which is the unlevered version of

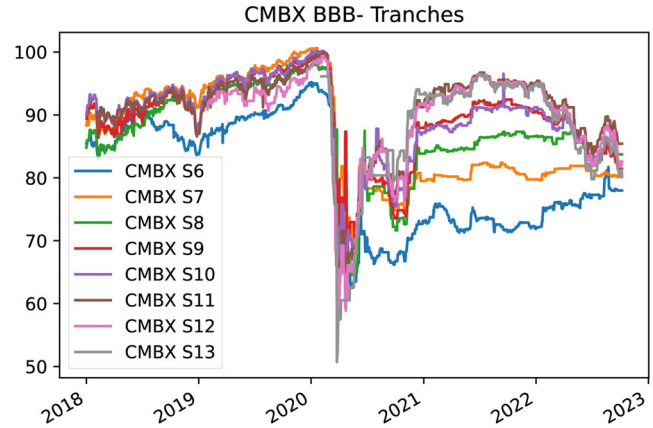


FIGURE 16 CMBX price for series [Color figure can be viewed at wileyonlinelibrary.com]
Source: Bloomberg

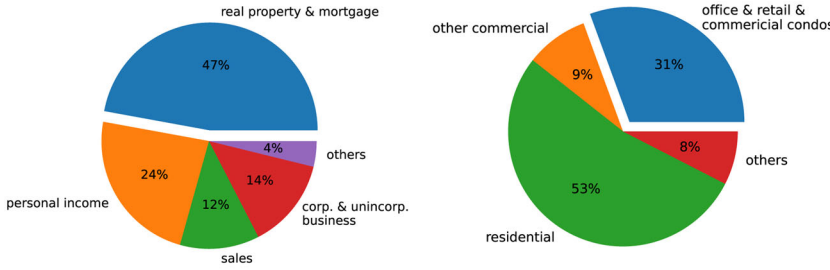
the same statistic, is –30%. The three NYC REITs trade at discounts of around 60%. Either large private equity funds like Blackstone and Brookfield should be taking these companies private or the stock market knows something that is not yet reflected in private NAVs. Historical evidence suggests that stock prices predict future NAV changes.

Debt

Commercial real estate debt is broadly held by banks, insurance companies, private debt funds, and securitization (CMBS) vehicles. Given typical mortgage leverage ratios of 55–65%, sometimes accompanied by additional junior debt, it is not inconceivable that even debt holders may lose some of their investments if and when office assets lose 30–40% or more of their value. Banks and insurance companies are levered entities that fulfill a crucial role in the modern economy. A substantial loss on their real estate portfolio could have ripple effects for credit provision and financial stability.

The CMBS 60-day delinquency rate across all CRE sectors spiked at the onset of covid and peaked at 10.3% in June 2020. It has fallen steadily since then, falling below 3% by September 2022. The office delinquency rate (for office loans in CMBS deals) reached 1.6% in September 2022, up a few basis points over its prior low.

One place to detect market price signals of distress in the office debt markets is in the CMBX market. The CMBX is an index of the 25 largest and most liquid CMBS deals. CMBX indices of different credit ratings summarize the behavior of the corresponding tranches of the underlying CMBS deals. Every 6 months, a new CMBX vintage is born comprised of the 25 largest deals originated in the past 6 months. CMBS deals typically contain a mix of collateral. However, the more recent CMBX vintages (series 11–13) contain a larger share of office as the earlier CMBX vintages (series 6–8), which contain more retail loans. Figure 16 shows that the prices of the CMBX BBB-tranche (the lowest-rated tranche that is still investment grade and usually quite sensitive to deterioration in credit conditions) of later vintages–with more office–have fallen relative to those of earlier vintages in 2022. This hints at a first sign of stress in office, seen through the lens of the debt markets. A more thorough investigation of these patterns is in order.



(a) Sources of NYC Tax (b) Sources of Property Tax

FIGURE 17 Sources of NYC tax (left) and property tax (right).
[Color figure can be viewed at wileyonlinelibrary.com]
Source: The City of New York Department of Finance (2022); Office of the New York State Comptroller (2022).

4.4 | Fiscal implications for local governments

Property tax revenues are a key source of revenue for municipalities accounting for between 20% and 40% of state and local tax revenue collections in nearly all states (U.S. Census and Tax Foundation).

The left panel of Figure 17 shows that property tax revenue accounts for 48% of tax revenue in New York City in fiscal year 2021. The right panel shows that office and retail real estate tax revenue constitute 35% of the $30.2 billion in total tax revenue (Office of the New York State Comptroller, 2022). The office sector alone contributed nearly $7bn in tax revenue to NYC's coffers in 2021.[14]

Rising residential real estate values increase property tax revenue, while declining office and retail real estate values decrease them. The net impact is heterogeneous across space, with suburban municipalities faring better than urban locations.

These tax implications will unfold gradually because of the gradual erosion of office real estate values and because the tax rate adjustment often follows market value changes with a lag. Property tax collections in NYC are expected to decline by 5.4% or $1.7 billion in fiscal year 2022, more than half of which is due to drops in billable values in the office sector.

Fewer commuters also reduce local sales tax revenue and ridership revenues for public transit systems.[15]

Remote work uptake may also affect local income tax revenue in places with a local income tax like NYC, depending on where hybrid workers will pay local income tax. More on this below.

The reduction in tax revenue resulting from WFH puts financial strain on local governments. Given balanced-budget requirements and limited ability to issue general obligation debt, cities with a budget shortfall need to either raise tax rates or cut government services, that is, reduce spending on local public goods, such as police, fire, and sanitation departments, transportation,

[14] This includes $6.3 billion in property tax, $100 million in property transfer tax, $115 million in mortgage recording tax, and $395 mi in commercial rent tax (The City of New York Department of Finance, 2022). This estimate does not include indirect contributions, including sales and personal income tax impacts. The property tax rate plays a special role in the NYC budget as the only tax rate that is under direct control of NYC government. It is the residual that balances the budget.

[15] Ridership data are available from multiple transportation agencies. For example, daily ridership in the NYC subway in early November 2022 is at 65% of prepandemic levels during weekdays (somewhat lower on Mondays and Fridays and somewhat higher on the other days) and 75% during the weekends.

public schools, and so on. Higher tax rates and/or lower government spending on public goods make the city a less attractive place to be for households and firms alike. Workers and firms with the best outside option and/or the highest tax rate have the highest incentive to leave. Their migration disproportionately hits the government's budget since a large share of local tax revenues come from a small share of the population. Higher taxes and lower public goods provision would exacerbate (prolong and potentially accelerate) the net out-migration that began in 2020. Fewer (high-income) people and (high-profit) firms would mean lower tax revenues and lower user fees for public transportation, deepening the fiscal hole. Tax rates and spending cuts would need to be larger still, prompting further out-migration. This *urban doom loop* would result in a municipal fiscal crisis. NYC experienced such a crisis in the 1970s, Detroit more recently.

Much of the adverse tax revenue impact in the 2020–2022 fiscal years has been offset by large federal government cash infusions as part of the various covid stimulus bills. State and local governments received $150 billion extra from the federal government in 2020 and 2021. More help is forthcoming under the Infrastructure and Inflation Reduction Acts signed into law in 2022, specifically in support of local infrastructure and clean energy investments. However, the fiscal largesse of the federal government toward local governments is slated to shrink substantially in fiscal year 2023 and beyond. At that point, some municipalities may find themselves entering in the doom loop scenario.

The magnitude of the doom loop depends on the elasticity of migration to local tax rates and public good spending. Giesecke and Mateen (2022) estimate substantial causal effects of property tax increases on residential migration. In a world where people can work remotely, these migration elasticities may be higher since people may not need to switch jobs to switch tax residence. Indeed, Gustafson et al. (2022) find that areas that experienced larger population outflows during covid saw increases in their municipal bond yields, hinting at increased risks of financial distress.

More anecdotally, corporate relocations away from high-tax locations, such as Illinois and New Jersey, also seem to be on the rise.

Remote work raises interesting questions for local taxation, both in practice[16] and theory (Agrawal & Brueckner, 2022).

4.5 | Implications for productivity and innovation

The short-run and long-run labor market and productivity effects of remote work are fascinating, and relevant to the discussion of real estate valuations because they are the ultimate drivers of firms' space decisions. Labor, productivity, innovation, and DEI scholars no doubt will study the impact of WFH for years to come. This section provides an initial, cursory discussion.

[16] In the United States, six states (New York, Massachusetts, Arkansas, Pennsylvania, Delaware, and Nebraska) levy income taxes on nonresidents for income that they earn while WFH. For example, more than 400,000 New Jersey residents commuted into New York and paid the state about $3 billion a year in taxes. The state of New Hampshire sued the state of Massachusetts over its remote work taxation policy. Ten states filed an amicus brief in support of New Hampshire's position. The U.S. Supreme Court refused to take up this case in August 2022. New Jersey is now pursuing a law that would retaliate against the state of New York by taxing New York residents who work remotely for New Jersey companies. See https://www.city-journal.org/remote-work-and-the-state-tax-war for more details.

4.5.1 | Individual labor productivity

So far, the evidence on whether remote workers are more or less productive than on-site workers is sparse and the effects are mixed. For most jobs in the modern service-sector economy, it is challenging to attribute output to individual workers (or even to teams). Research has mostly focused on a few occupations where that attribution is easier (call centers, patent officers, software developers, and scientists), but a reasonable question is how representative these industries are for jobs that are less routine or more team-based, and hence for the economy as a whole.

At a sectoral level, Fernald and Li (2021) show that all productivity growth came from industries where remote work was feasible, as measured by the Dingel and Neiman (2020) occupational teleworkablility scores. Looking at productivity during the early part of covid, Bloom et al. (2022) find a modest decline in total factor productivity (TFP), with reductions within-firm and small gains across firms, from less productive firms shrinking.

Several micro studies find gains in productivity from remote work in specific settings. Bloom et al. (2015) and Emanuel and Harrington (2022) find that call center workers are more productive when they work from home. Bloom et al. (2022) find that hybrid work increases productivity among software developers in a randomized control trial in China. Lines of code written increase by 8% and self-assessed productivity increases by 1.8%. Job satisfaction increases and attrition decreases by 35%. Choudhury et al. (2021) study patent officers who are randomly assigned from a WFH to a work-from-anywhere program. The added geographic flexibility increases their productivity by 4.4%.

Aksoy et al. (2022) find self-reported productivity gains over the covid episode of 7% across 30,000 workers in 27 countries surveyed in July 2021 and Feb 2022. These self-reported productivity gains are strongly positively correlated with the numbers of days worked from home, and with employers' expected remote work days after covid. This suggests that self-assessed productivity at least directionally lines up with employers' perceptions and contains valuable information about productivity.

There is also evidence that remote work reduced productivity. Gibbs et al. (2021) find that forcing skilled professionals at an Asian IT firm to work from home led to a 10–25% decline in productivity. In their comprehensive survey of employers, Barber et al. (2021) report a 20% average decrease in productivity during the pandemic as a result of WFH. In their survey of NABE economists, Bartik et al. (2020) report a nearly 30% decrease in productivity from WFH. Morikawa (2020) presents survey evidence showing that most employees consider themselves less productive at home, but that productivity increases as employees become more familiar with WFH technology.

Lin et al. (2022); Yang et al. (2022) find short-run increases in productivity. Longer term, teams become more "siloed" and exhibit less synchronous communication.

Although Kruger et al. (2020) report greater output of finance academics during COVID-19, this is likely because of greater input of hours and the particular task of completing papers early in the pandemic. In their study of finance academics, Barber et al. (2021) find that feelings of isolation and the inability to obtain feedback as a result of WFH decrease research productivity.

Indeed, part of the positive productivity effects may be coming from employees working more hours.[17] Or it could result from finding a better work–life balance (including getting more sleep), resulting in less stress and better quality work per hour worked.

[17] Data from Microsoft Worklab (2022a) show that the average Microsoft Teams user saw a 252% increase in their weekly meeting time between February 2020 and February 2022, and the number of weekly meetings has increased 153%. The

People report being very satisfied with their remote work experience, being willing to give up about 5% of pay for the ability to work remotely 2–3 days per week, and being likely to look for other work should the remote work benefit be removed (Barrero et al., 2021). Similarly, Mas and Pallais (2017) find that call center workers are willing to take an 8% pay cut to work from home.

4.5.2 | Beyond individual productivity

Many have argued that remote work makes it harder for firms to establish and maintain corporate culture. WFH may also make it harder for new/young employees to receive mentorship, develop professional norms, and absorb corporate culture. Young employees may be building less human capital as a result. If some of that human capital is embodied in the worker and not in the firm, the underinvestment due to remote work represents a negative externality from remote work (Becker, 1962). A loss of corporate culture or employee mentoring may make recruiting talented employees harder. Emanuel et al. (2022) find that in-person proximity increases feedback from co-workers among software engineers, which is particularly important for young and female engineers. This advantage was lost when offices closed. Online feedback is not a substitute but a complement to in-person feedback.

The benefits of remote work are tangible, immediate, and easy to measure, while the costs are more opaque, longer-term, and harder to measure (at least at this point).

4.5.3 | Selection and coordination

Before covid, workers who opted for remote work may have been adversely selected, attaching a negative stigma to WFH (Bloom et al., 2015). Such selection concerns are absent in the early stages of covid, due to the forced mass adoption of remote work. They may resurface now that many employees are given the choice of coming in. Perceived or real advantages of face-time with the boss may result in selection effects on unobservables, such as career ambitions. This will complicate future research at least when using data for companies where employees have discretion on coming in.

Atkin et al. (2022) use a random assignment of workers to on-site and remote work in India to quantify not only productivity losses associated with work (data entry) from home but also negative selection effects on treatment. Those who prefer work from home are much less productive at home than in the office.

Another issue that complicates simple inference is that of multiple equilibria. *If WFH is associated with higher productivity*, but it is individually rational for an employee to come in (to get ahead, to gossip at the water cooler, to get away from a screaming baby), other employees may feel forced to come in as well even if they would prefer not to. This could explain why we may have been stuck in the wrong equilibrium before covid, and the pandemic forced us into the good

average Teams user sent 32% more chats each week in February 2022 compared to March 2020. Workday span for the average Teams user has increased more than 13% (46 min) since March 2020, and after-hours and weekend work has grown even more quickly, at 28% and 14%, respectively. Data from a follow-up study in September 2022 (Microsoft Worklab, 2022b) show that these trends continued. Moreover, the incidence of overlapping meetings (being double-booked) increased by 46% per person in the past year. Meeting declines increased by 85%, and in an average week, 42% of participants multitask during meetings by actively sending an email or ping.

equilibrium. Conversely, *if WFH is associated with lower productivity*, then coordinating on coming into the office is good for everyone. But if nobody is in, it is not individually rational to come into the office.

This coordination issue raises questions about the stability of hybrid work arrangements. The promotion rat race may induce young employees to come in 5 days a week even if the company only mandates 3, and even if 3 is the optimal number.

Unless employees (in a given team) coordinate on which days of the week they come in, they may find themselves spending more time on zoom while in the office and unable to take full advantage of face-to-face interactions. Team-building, brainstorming sessions, group meetings need to be coordinated. This requires removing employee flexibility on when to come into work.

4.5.4 | Relationship with office demand

The above discussion has direct implications for office demand. If all employees in a given location are asked to be in the building on Wednesday each week, the company may not be able to reduce its office demand by much compared to the situation where all employees come in every day, at least under current leasing arrangements. There could still be some space savings from reconfiguring the office with more meeting space and less individual work spaces.

But if different teams within the firm can coordinate to come in on different days, then the office savings could be much more dramatic. Larger companies may find it easier to achieve space savings from such rotation.

Over time, landlords will change office layouts as well as the structure of leasing contracts to meet the needs of the tenants. They could build a large auditorium on the ground floor and large meeting rooms on the second floor of an office building that can be rented out 1 day per week to each of the five tenants that rent private space with hot-desking on the higher floors of the building. Landlords could lease out the same space to multiple firms at once, each for some predefined number of days or even hours. In this world, there is a larger role for companies that facilitate the sharing of office space.[18] Load-balancing software, similar to what WeWork pioneered, could be used to greatly increase the efficiency of the building. In such a world, a fully occupied building may be able to become a lot more profitable while simultaneously reducing office rents for all its tenants. The effect of such efficiency gains in space utilization would result in a *much larger* aggregate reduction in office demand than under the current inflexible leasing arrangements where one tenant needs to reserve some fixed space for the next 5–10 years.

It is not hard to imagine that smaller and/or more financially constrained companies close their office space, go remote, and rent limited desk or meeting space as needed.

4.5.5 | Innovation

The effects of remote work on innovation are even less well measured and understood, and may take even longer to properly assess than the effects on productivity. What little evidence we have is again from specific settings that may not be representative of the (office-using) economy as a whole.

[18] The company Codi facilitates the sharing of the same office space among multiple tenants on alternating days (Wall Street Journal, October 24, 2022).

Chen et al. (2022) find that the effect of remote collaboration on breakthrough discovery becomes positive in 2010s. Atkin et al. (2022) find that face-to-face interactions result in more patent citations. Catalini (2018) finds that labs are more likely to collaborate after random shock results in colocation, but disruption does not decrease collaboration. Proximity is particularly important for starting collaboration. Roche et al. (2022) show that startups are more likely to adopt technology used by randomly allocated proximate peers.

Haltiwanger (2022) shows that, unlike other recessions and the Great Financial Crisis, the covid crisis was associated with strong business formation. Interestingly, the spatial pattern of business formation changes compared to the pre-covid period. There are fewer new businesses in the urban centers and more in the suburbs. He documents not only an increased suburban presence in the nonstore retail and food & accommodation sectors, but also in professional, scientific & technical services, more directly associated with innovation.

4.5.6 | Using firm-level outcomes

The above discussion has made clear that measuring the overall effects of WFH on productivity and innovation is challenging. There are many channels and severe measurement challenges. One complementary approach to direct measurement is to infer the productivity effects indirectly from firm-level outcomes.

Firm profits

One such outcome is firm profits. All else equal, if WFH boosted worker productivity, then this should show up in firm profits. This requires that firms capture at least some of the extra productivity. Kinder et al. (2022) study 22 of the largest U.S. firms that collectively employ 7 million workers, and find that workers captured a very small share of the revenue and profit increases during the pandemic.

Even when researchers find a clear link between remote work and firm profits, causal inference is challenging. The demand for certain goods and services was differentially impacted by the pandemic across sectors for reasons unrelated to remote work. The macroeconomic environment was experiencing unprecedented shocks that differentially impacted firms. Subject to all these caveats, record profits for many firms seem *prima facie* inconsistent with the notion that remote work lowered productivity substantially. Anecdotal evidence suggests the opposite. Office-using companies transitioned nearly seamlessly to fully remote operations, employees worked harder and more efficiently supported by technological and process innovation, and companies generated record profits.

Stock returns

Current revenues do not reflect the impact of WFH on long-run productivity and innovation. However, stock prices, which are the present discounted value of all future payouts to shareholders, may. Indeed, one of the most prominent procedures for measuring the value of innovation is to study the stock market impact to patent announcements (Kogan et al., 2017; Kelly et al., 2021). Subject to the same caveat that stock market reactions capture many other things besides remote work, stock returns are higher for companies with higher ability to work remotely over the covid period (see the WFH equity factor in Gupta et al., 2022). To aid identification, future work could look at stock market reactions in shorter windows around corporate announcements of remote work plans.

Lease decisions

To circumvent at least some of the aforementioned difficulties of confounding factors, a natural idea is to study firms' active space decisions. Many office tenants have actively reduced office use (in total, and per employee). By revealed preference, they have concluded that the value of the space they gave up was lower than its cost.

Letting employees work form home some or all of the time must be perceived by the firm to not reduce productivity by more than the cost of the office space. For example, a typical office employee consumes about 400 square feet of office (including conference and meeting rooms, bathrooms, lobby, etc.). At an average cost of $40 per square foot, the national average net effective rent over the past 5 years, this amounts to $16,000 in office costs per employee. Office workers make $42,000 per year on average in the United States. The office expense is, therefore, a nontrivial cost for firms, relative to salaries. Assuming a labor share of 2/3, typically used in macroeconomics, the firm's share of an employee's output is $21,000. The office cost consumes 76% of the employer's share. This simple calculation suggests that firms can dramatically improve profitability by cutting office expenses. This is true even if they allow worker to work from home without pay cut–workers indicate being willing to give up 5% of pay for the ability to work remotely at least some days per week–and does not reflect the extra benefit to firms in terms of employee satisfaction, retention, and recruitment than come with offering more flexible work schedules. The gains are naturally smaller if the square foot reduction per remote or hybrid employee is smaller than 400 square feet. Improvements in office utilization are likely to materialize that will allow firms to capture a nontrivial boost in profits from a reduced footprint.

The above calculation seems to apply directly to a large cadre of lower- and medium-skill office workers performing routine cognitive tasks, for example, back-office workers. For higher-skilled, higher-paid workers, the cost of office represents a smaller share of compensation. But these workers may consume more expensive office space (in A+ buildings in superstar cities), and they may capture a larger share of their output (Eisfeldt et al., 2021), so that the office cost may still represent a nontrivial component of the firm's share of their output. Furthermore, it is conceivable that these employees are substantially more productive if they can work at least some days from home, for example, to do research or other cognitive tasks that require quiet time, and that they are more likely to quit if they do not receive the WFH days they desire.

The massive decline in newly signed leases in the Compstak data between early 2020 and mid-2022, shown in Figure 10, is consistent with firms voting with their dollars, and recognizing the economic logic of the argument made above.

Gupta et al. (2022) also connect firms' remote work practices to office space decisions. They find larger space reductions for those firms that work fully or mostly remotely, followed by firms with hybrid work schedules. Firms that are mostly in-person experience the smallest change in office floorspace leased.

Job postings

To establish a further connection between remote work and active tenant space decisions, Gupta et al. (2022) use Ladders data on the share of remote job postings in overall job postings by tenant and that tenant's change in office space leased over the past 2 years, adjusted for employee growth. They find a robust and economically significant negative relationship.

By revealed preference, if firms had bad experiences with remote work, they would not post new jobs with fully remote or hybrid work schedules. Taking a more aggregate perspective,

time-series evidence from Indeed, shown in Figure 4, shows instead a sharp increase in the share of jobs that is remote.

4.6 | Implications for the climate

The onset of the covid-19 epidemic was associated with a significant reduction in greenhouse gas (GHG) emissions as people stopped commuting and traveling. Global fossil CO_2 emissions fell 5.4% in 2020. Those gains proved to be temporary. GHG emissions rose by 4.2% in 2021 as the economy rebounded strongly (Jackson et al., 2022).

Remote work has nuanced implications for GHG emissions. Smaller urban apartments emit much less carbon than suburban single-family houses. Commuting by foot, bike, or public transit, all of which are much more common in urban than in suburban areas, is much better for the environment than commuting by gas-powered cars, the dominant mode of transportation in the suburbs. The rise of remote work then has ambiguous effects on emissions. It cuts down on gas-powered car commutes because suburbanites can work from home more on the one hand. On the other hand, the adoption of remote work policies may increase the fraction of the population living in the suburbs, thereby increasing the number of people commuting and possibly the length of their commute, increasing emissions from larger housing units, and reducing the share of low-impact urban commutes. Quantifying what effects remote work has on overall GHG emissions and on the geographic distribution of emissions is an interesting direction for future research (Kyriakopoulou & Picard, 2021).

Finally, new construction generates much more emissions than existing buildings. To the extent that remote work triggers more construction in the suburbs and in smaller metros, and demolition of office buildings that are replaced by new construction in the urban areas, it may generate substantial new emissions.

5 | POLICY IMPLICATIONS

As discussed above, the absence of a large portion of office workers in urban centers jeopardizes not only the returns for private investors in urban office and retail real estate, but has potentially broader spillovers to the financial health of the banking sector, the local retail sector, and local government, thereby impacting the provision of local public goods (safety, the transportation system, etc.). Remote work also reduces the positive externalities from agglomeration typically associated with urban areas. While progress in digital communication may have reduced those positive agglomeration effects even before the pandemic, it certainly did not eliminate them. Finally, it may also lead to underinvestment in worker-specific human capital. These are negative externalities from remote work since private employers do not internalize those when setting remote working policies. It is these local negative externalities from remote work that constitute a rationale for intervention by local governments in urban areas. Whether such intervention improves welfare for society as a whole is another matter. Policies that benefit urban governments may negatively impact suburban governments. And policies that promote a return to the office may offset productivity gains from remote work, if those gains are positive.

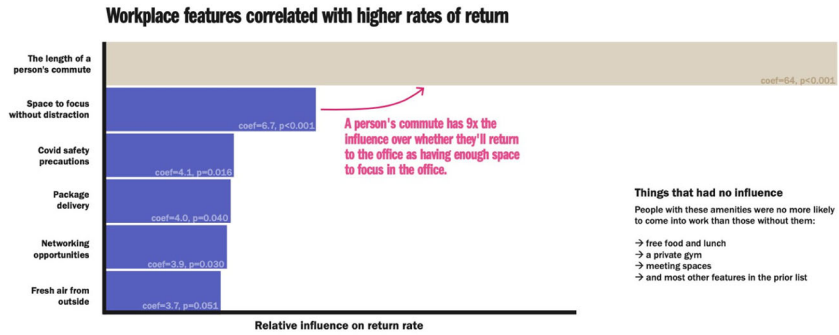


FIGURE 18 Factors affecting office return.
[Color figure can be viewed at wileyonlinelibrary.com]
Source: The Magnetic Workplace: 2022 Workplace Futures Survey.

5.1 | Return-to-work mandates for government employees

One policy response is for local authorities to force government workers back to the office and to arm-twist private employers to do the same. This has been the strategy of the NYC Mayor Eric Adams, with the strong endorsement of the Real Estate Roundtable. Several large banks, most prominently Goldman Sachs and JP Morgan, announced a return to the 5-day on-site workweek in September 2022. However, government workers are not numerous enough to single-handedly turn the CBD around. Moreover, the city risks losing its most talented and experienced employees to private sector jobs, if the latter offer more remote-work opportunities. The success of this strategy, therefore, relies crucially on private-sector adoption. But the latter will ultimately depend on firms' experience with remote work, and its short-term and long-term consequences for profitability. Based on the evidence presented above, there is no reason to suspect a massive and voluntary return to the office-first strategy by the private sector.

5.2 | Subsidies for return-to-office

The government could impose a tax on unutilized office space, in order to spur a return to the office. However, office landlords would face difficulty passing on this tax to tenants in the currently weak leasing market, in which case, it would fail to reach its intended goal. Instead, this tax would place further stress on landlord after-tax cash flows, lowering office values, and precipitating the decline of the urban office market. Furthermore, such a tax would be hard to enforce as actual office use is nontrivial to measure; using turnstile data would be one way to do it.

Providing subsidies for return to the office could work better. These could either go to landlords, who could pass them through to tenants or use them to pay for amenities that improve the office experience, or directly go to tenants. Tenants could use the subsidies to provide free meals and other in-office benefits or to offset their employees' commuting costs. It is an open question what the elasticity of days in the office is to such a subsidy. Presumably, that elasticity will depend on the (time and financial) cost of commuting, on the productivity gains or losses from being in the office for an extra day, and on the eagerness of senior management to return to the office. One key determinant of the number of days worked from home is length of commute. It dwarfs all other determinants, see Figure 18 and Aksoy et al. (2022). WFH days do not respond to free meals.

If the friction is commuting time, and not cost, and if employees' work location choices do not respond to incentives such as free meals, then the elasticity may be low and the policy ineffective. Improving commuting time, discussed below, may be a more effective policy.

5.3 | Conversion

In the scenario where remote work policies remain ingrained or gain further traction, the remote work revolution has created a spatial real estate mismatch. There is too much urban office and office-user-oriented retail and too little suburban housing. In many locations, there is also too little urban housing. Urban office can shrink only through two mechanisms: demolition and conversion to alternative use. While some conversion to health care (medical office), life science, data centers, and industrial real estate may make sense, the most commonly mentioned conversion option is from office to apartment (OTA).

There is ample evidence that the superstar cities face a housing shortage, which is particularly acute for affordable housing. For example, the NYC housing vacancy rate was 3.6% in 2017. That housing vacancy rate did increase to 4.5% in 2021 according to the NYCHVS, but remains low. The NYC rental vacancy rate is much higher for more expensive apartments (12.6% for units with monthly rent above $2300 per month) than for cheaper apartments (1% for units with rents below $1500 per month). Similarly, Manhattan apartment vacancies reached 10% in the period between February and July 2021, the time of the latest NYC housing and vacancy survey, while the Bronx had less than 1% vacancy. The affordable housing crisis has been aggravated by the sharp increase in rents between mid-2021 and mid-2022. It is thus a logical question whether some of the surplus office can be converted into housing. The falling office and rising apartment rents have made this a financially more attractive proposition.

There has been a lot of discussion around the (1) structural, (2) regulatory, and (3) financial viability impediments to OTA conversions. On the structural/physical side, there is the question of whether the large floor plates of modern office buildings are compatible with apartment layouts. The floor plates of glass-and-steel skyscrapers may contain too much interior, windowless space so that too few apartments can be created. This interacts with regulatory considerations (such as rules that stipulate that a bedroom must have a window), and with the concerns of financial viability of such conversions. Other regulatory impediments may be that an area is zoned for office but not for residential use. Finally, even when the physical layout is suitable for conversion and the regulatory hurdles can be cleared, the project may not be financially viable. Construction costs for such a major change of use are substantial, especially given the increased cost of raw materials and construction labor, and the cost of land in urban centers. Developers typically target the luxury apartment market segment in such conversions. For OTA conversions to make financial sense, the basis (purchase price) must be low enough and the luxury condo or rental market strong enough. This may require that the existing office owner sells at a steep loss. The price at which office owners would be willing to sell may not allow for profitable conversion, while the price at which buyers can profitably create apartments is not one at which the owner is willing (or able, due to the presence of a mortgage) to part with the asset.

Older office buildings may be more conducive to OTA conversion due to their physical layout. Interestingly, it is these older, class B and C office buildings that suffered the greatest valuation losses according to our analysis above. Hence, the covariance between building valuation and conversion potential is negative, which should help the economics of conversion.

SupplyTrack records planned development and redevelopment on average 18 months before the projects start (Cunningham & Orlando, 2022). Its data on multifamily housing conversions from an existing use show a slowdown of conversions from around 2500 projects per month to 1500 per month in the year to June 2022. The June 2022 data indicate a low level of conversion not seen since the Great Financial Crisis (2008–2011), and are far below the peaks of 2006 and 2015, when there were about 3500 monthly conversion projects. Proxying conversions from office to multifamily by looking at large multifamily conversions (50+ units), the data similarly indicate a slow and declining pace of conversion. A CBRE analysis (CBRE, 2022) finds that cumulative OTA conversions between 2016 and 2026 (including all planned conversions as of November 2022) amount to only about 2% of the office stock, even though conversion activity will likely pick up the pace in 2023 and beyond. More research is needed on the return on such conversion investments with and without government support. Another important research question is how much the ROI would compress in an environment where such conversions became more common, that is, in general rather than in partial equilibrium.

To summarize, the private market may not reach the socially desirable extent of OTA conversion. Or the socially desirable amount of OTA conversion could only take place at transaction prices that wipe out office owners and inflict losses on their lenders. Such losses by the financial sector may have further ripple effects on the real economy.

This leaves a role for government policy to promote adaptive reuse. Landlords could receive subsidies for OTA conversion projects. Those subsidies could be larger for projects that create (some) affordable housing and in locations where the gap between social and private benefit from conversion is higher. They could target buildings that are most suitable for conversion, such as the older class B and C buildings, where subsidies may be more modest but existing owners have shallower pockets.

Municipal governments have begun the conversation of how to stimulate OTA conversion in order to revitalize downtown areas and repurpose them for a remote-work world. City government could promote adaptive reuse by rezoning commercial and manufacturing areas for residential use, updating to the building code to facilitate conversion, and providing subsidies for conversions through tax credits, municipal bond financing, property tax abatements, and so on.[19]

How to pay for such subsidies? The subsidies will generate revenue in the form of higher property taxes from newly constructed apartments, income tax revenue from their tenants, and sales tax revenue from tenants' local spending that likely exceed the tax revenues from current use. Whether these additional revenues are large enough in present value terms to generate the necessary subsidy, and for what type of apartment units in which locations, is an interesting empirical question for future research.

[19] OTA conversions in Battery Park City in downtown Manhattan after 2001 is one example. Calgary embarked on a large-scale government-subsidized conversion in 2015. California's 2023 budget allocates $400 million in incentive grants for office-to-residential conversions. Chicago, Washington, DC, Los Angeles, New York City, Denver, among others, have set up task forces to study the issue and discuss policies. Real estate trade association REBNY estimates that a "conservative" conversion rate of 10% of NYC's lower-tier office buildings could generate approximately 14,000 new residential units. A study by the Rand Corporation (Ward & Schwam, 2022) identified underutilized commercial properties that could produce about 70,000–110,000 housing units in Los Angeles County.

5.4 | Transportation and safety policy

Mass transit systems face large financial shortfalls due to reduced ridership. Crime has risen in urban areas since covid. Health and safety concerns increased the share of trips by car at the expense of mass transit. This is undesirable from an environmental perspective as well as a congestion perspective. Maintaining and further improving urban infrastructure, defined broadly to include public safety, is a necessary condition to retain existing and attract new residents to the city and bring commuters back to their offices.

Congestion pricing, a policy recently introduced in NYC, is a good step both to reduce road congestion and to create a new revenue stream to fund public transit. Reducing car reliance by reducing street parking and increasing the bike lane network would further increase healthy commuting options and reduce GHG emissions. The U.S. cities remain far behind their European counterparts in terms of the quality and quantity of mass transit, bike infrastructure, and air quality.

6 | CONCLUSION

The pandemic and its aftershocks have changed the real estate investment landscape both for the short- and long-run. One of the pandemic's longest-lasting impacts will be wider adoption of remote work. In this article, I review what we currently know from data and theory about the implications of WFH for real estate valuations and the structure of cities. I discuss broader implications for investors in equity and debt markets, productivity and innovation, local public finances, and the climate. Much is left to be explored. As more data come in, our theories will be refined and become even more useful for policy analysis. I sketch a few policies that may be worth exploring.

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