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Telecommuting and the Open Future

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16. Abstract
The COVID-19 pandemic has generated renewed interest in how telecommuting can alter the workings of our cities and regions, but there is little guidance on how to align planning practice with the new reality. This report synthesizes the research on telecommuting and its consequences to help planners better understand what effects may occur from the proliferation of telecommuting and what lessons can be drawn from research findings. Emphasis is on the broad relevance of telecommuting to many domains of planning, including housing, land use, community development, and inclusive place-making, while attention is paid to changes in travel demand, vehicle miles traveled (VMT), and greenhouse gas emissions. The research suggests that telecommuting can occur in a variety of ways, and its impacts are largely dependent not only on the type/schedule of telecommuting but on the built environment, transit accessibility, and other amenities/opportunities the location provides. The varying impacts reported in the research can be seen as an encouragement for planners to actively create a better future rather than merely responding to the rise of telecommuting. Given the breadth of telecommuting's impacts, systematic coordination across various planning domains will be increasingly important. This report also calls for collaboration across cities to guide the ongoing transformation induced by telecommuting not in a way that leads to more residential segregation but in a way that provides more sustainable and inclusive communities.

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Telecommuting and the Open Future

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Executive Summary

The COVID-19 pandemic has reignited interest in new work arrangements, particularly telecommuting. Shelter-at-home policies forced businesses to rapidly develop a telework infrastructure to continue their operations to the extent possible. In the wake of the pandemic, the prevalence of telecommuting has become the new normal, although this varies across industries. New questions arise from this rapid technological adoption. *How will telecommuting growth affect our cities? Should planners be worried about telecommuting growth? How should planners deal with this proliferation?*

To address these questions, this report provides a synthesis of the current research concerning how increased flexibility in the work-home arrangement is changing the nature of commuting. Although the research suggests that telecommuting can have impacts not only on travel demand but also on many other building blocks of our cities, such as housing, land use, and community services, the research findings are largely equivocal about telecommuting's impacts on the workings of cities. When research findings are mixed, it is preferable not to see things through a deterministic lens. Rather, it may be more beneficial to focus on which contextual factors or planning and policy initiatives can lead to better desired futures.

Before taking a deeper dive into telecommuting, it should be noted that scholars have defined telecommuting in diverse ways. There are telecommuters typed by their work location and their frequency of telecommuting. Various spatial types of telecommuting include but are not limited to center-based telecommuting and home-based telecommuting. Telecommuters are sometimes categorized as part-time, part-day, or full-time telecommuters. Appendix A provides a brief summary of these varying definitions and types of telecommuting that need to be carefully considered when digesting what has been reported in the research literature.

How will telecommuting growth affect our cities? The research findings are mixed in part due to the various definitions (and possibilities) of telecommuting used and the varying contexts in which it takes place. For instance, while studies often report that telecommuters tend to choose residential locations that are further from their traditional workplaces compared to non-telecommuters, it is not clear whether the choice to telecommute directly affects their decision of where to live. It has also been suggested that changes in urban spatial structure may take place in complex ways rather than a simple exodus from downtown to the suburbs. Telecommuting's impacts on business location choice are also understudied, although it is evident that many business establishments also gain increased flexibility in deciding where to locate when their workforce is not tied to a single location. According to the research, however, the central business district (CBD) and other locations may need to be prepared for the changing demand for various land uses and community services as telecommuting proliferates.

Should planners be worried about telecommuting growth? A key concern in the telecommuting research centers around the sprawl inducing effects of telecommuting (since workers can choose to live further from the office) which can lead to more greenhouse gas emissions from increased vehicle miles traveled (VMT). Telecommuting

is complex in the way it affects human behavior, and it is important to note that not all trips (both work and non-work) are taken with a single occupancy vehicle. Telecommuters frequently take sustainable transportation modes, and this decision appears to be associated with the nature of the local built environment, such as transit accessibility and neighborhood walkability. A less discussed concern about telecommuting growth is the uneven distribution of telecommuting options which could widen the digital divide. Telecommuting provides benefits such as increased accessibility and flexibility, but it is not readily available to everyone equally due to high costs and the limited availability of reliable high-speed internet in some areas. The increase in the number of telecommuters and their ability to relocate can result in greater residential segregation or further digital divide, if not properly managed.

How should planners deal with this proliferation? Planners can make a difference in shaping the future with increasingly diversified work-home arrangements, although the proliferation of telecommuting is not under the full control of individual planners or planning agencies. Since the impacts of telecommuting are not limited to changes in travel demand (and thereby VMT and greenhouse gas emissions) but rather have broader consequences for virtually all areas of planning, conscious efforts need to be made to promote greater coordination among planners. While new initiatives can be devised, the usefulness of some existing programs should not be underestimated. Traditional planning strategies, such as limiting greenfield development and the push for mixed-use multi-family housing, can help cities grow more sustainably. Making alternative transportation modes more competitive against single occupancy vehicles can serve telecommuters as well as traditional commuters. Interjurisdictional collaboration may also better serve cities in preparing for a more equitable digital age with reduced inequality and residential segregation.

It is our hope that all these planning efforts will be continuously informed by further research on telecommuting and its evolution. Most of the studies reviewed in this report took place before the COVID-19 pandemic. Much has changed since the pandemic regarding society's interpretation of what telecommuting is, how to take advantage of this new form of work-home arrangement, and how one can repurpose the time, budget, and space saved from not having to commute every day. Human behavior may continue to change, and more should be known about these rapidly evolving changes and the longer-term consequences of telecommuting.

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Introduction

Recent years have seen a significant rise in nontraditional forms of work-home arrangements, often called 'telecommuting.' While the recent proliferation of telecommuting is in large part due to the COVID-19 pandemic, it has been suggested that the new normal will not likely be returning to the pre-pandemic state. Rather, the trend toward, or the prevalence of, various forms of work-home arrangements, is likely to persist in the future. Data from Canada shows that more than 60 percent of workers never telecommuted before the pandemic yet less than 35 percent would prefer to go back to their pre-pandemic commutes in the future (Fatmi et al., 2022). According to the Pew Research Center, the share of workers telecommuting started at 23 percent pre-pandemic and rose to more than 70 percent at the peak of the pandemic. In 2022, around the tail-end of the pandemic, about 59 percent of workers in the U.S. worked from home part or full time (Parker et al., 2022).

What does the increasing popularity of telecommuting mean for urban planning? While few would disagree that telecommuting can reshape the workings of our cities and regions in many ways, there is little consensus on what the new reality would look like and how planners could better prepare society for the changes. Some anticipate that the rise of telecommuting will pose a significant challenge to creating more compact and mixed communities by allowing households to relocate to remote locations, whereas others see telecommuting as an opportunity for travel demand management and the reduction of greenhouse gas emissions.

This report provides a synthesis of the research concerning what this increased flexibility in the work-home arrangement might entail. While the project team reviewed over 100 academic journal articles (identified through a search using EBSCO Academic Search Complete and the Web of Science), all of which provided insights into telecommuting and its broad consequences, the following sections focus on what specific lessons could be drawn for urban planners and policy makers. Before presenting our analysis, however, it should be noted that scholars have defined telecommuting in various ways (Asgari & Jin, 2015; Paleti & Vukovic, 2017; Pratt, 2000). There are also various types of telecommuting, such as center-based telecommuting and home-based telecommuting. Appendix A provides a brief summary of these varying definitions and types of telecommuting that need to be carefully considered when digesting what has been reported in the research literature.

Throughout this report we wish to convey to the reader that telecommuting is a complex phenomenon with many uncertainties. Given telecommuting's complexity, it is likely to affect all areas of planning—not just transportation and environmental planning. Whether telecommuting can help advance major California planning goals, such as greenhouse gas reduction, congestion mitigation, robust local economic development, or housing affordability, remains uncertain. However, this does not mean there is nothing urban planners can do to produce more desired futures, and it is particularly important to explore ways to better coordinate across all areas of urban/regional planning, across municipalities, and across different levels of government.

Location Choice

One immediate conclusion from current research on telecommuting is that households can have more location choice options as their physical ties to workplaces are loosened. The rise of telecommuting can also directly or indirectly affect the location choice of businesses, though much of the research focuses on what would happen to households rather than business establishments as discussed below.

Household Location Choice

How does telecommuting affect household location choice? Researchers have examined this question by comparing telecommuters with those who do not (or are not allowed to) telework. While such comparison does not always enable one to precisely capture the true cause-effect relationship (see Appendix B – Directional Relationship and Causality), these studies provide a valuable opportunity to understand the relationships between telecommuting and household location choice, often with a focus on (1) relocation distance from the office or (2) whether relocation is in the city center, suburb, urban periphery, or a rural area.

Differences exist between telecommuters and non-telecommuters. Several studies suggest that telecommuting households tend to choose locations with longer distances from their workplace than non-telecommuting households (Jin & Wu, 2011; Mokhtarian et al., 2004; Zhu, 2013; Zhu & Mason, 2014). One study shows that those with one-way commute distances greater than 25 miles are more likely to telecommute (and telecommute more frequently) than those with shorter commute differences (Sener & Bhat, 2011). This association of longer commute distances with telecommuting is perhaps due to telecommuting being seen as a way to reduce expensive living costs associated with urban areas and reduce transportation (commuting) costs (Ellen & Hempstead, 2002). Therefore, telecommuters are "slightly less likely to live in central cities than the [total] workforce" (Ellen & Hempstead, 2002, p. 759).

Although telecommuting may be associated with longer commute distances, telecommuting is not necessarily the cause of long commute distances (Paleti & Vukovic, 2017). There is a possibility that those who could telecommute relocated to more suburban areas, leading to that longer commute. It is important to take the results of some of these empirical studies with a grain of salt particularly when they are not based on long-term observations. For example, it may be hard to determine whether a telecommuter changed jobs to a place closer to their relocated home post-survey. This may convert a telecommuter to a short-distance commuter. One study notes that workers may "evaluate work and residence locations based on their *expected* future accessibilities (and those of other workers in the household)" (Helling & Mokhtarian, 2001, p. 521). In one 10-year dataset with a small sample size, scholars found that the "temporal order" of telecommuting and household relocation matters (Ory & Mokhtarian, 2006). More specifically, workers interestingly tend to move closer to the office if they relocate their residence after telecommuting (Ory & Mokhtarian, 2006). Conversely, workers tend to move further from the office if they telecommute after relocating (Ory & Mokhtarian, 2006).

Admittedly, household location choice is a complex process, and telecommuting would not necessarily lead households to relocate in a single direction (e.g., out and away from the city center). There are studies which report that telecommuters are thriving in the urban center. For example, an econometric model examining telecommuting choice using a 2007 workplace commuter survey from the Transportation Department of the City of Edmonton, Canada shows that those residing closer to the main office telecommute more often than those living further away (Nurul Habib et al., 2012). In an investigation of whether telecommuters choose to move to less dense places, Ellen and Hempstead (2002) did not find a strong link between telecommuting and suburban location. The same study looked at self-employed telecommuters who have more flexibility to relocate because they are not tied down to a main office, and found they tended to move closer to the urban center (Ellen & Hempstead, 2002). A 2007 study examining household location choice of work-from-home employees in the Canadian cities of Montreal, Toronto, and Vancouver found that telecommuters tended to reside in high-income urban centers (Moos & Skaburskis, 2007). A Korean study cited in Kim (2016) reports that telecommuters often relocate to the urban center and relocate less than commuters. Using 1987-1990 data for California state employees, researchers reported that telecommuters had longer average commutes than non-telecommuters (Nilles, 1991). However, there was no meaningful differences in average relocation distance between telecommuters and non-telecommuters (Nilles, 1991). Through a forecast model, another study notes that although employees with long commute distances choose to telecommute earlier, the average commute distances of commuters and telecommuters were not significantly different from each other once the share of telecommuting employees increases (Vu & Vandebona, 2007).

It should also be stressed that not all telecommuters are the same, and some recent studies pay special attention to how telecommuting affects a two-worker household. From an environmental (or VMT) perspective, the ideal conclusion would be that for two-worker households with one telecommuter, the household moves closer to the office that the physically commuting worker must go to. One study, however, shows that within such households, the telecommuter does not influence the non-telecommuting worker's commute distance and duration (Zhu, 2013). This means that there is not always a total household reduction in VMT in a two-worker household with one telecommuter because the household does not always move closer to the non-telecommuter's office. Conversely, a UK study finds that two-worker households with a telecommuter may lead to the redistribution of travel to minimize VMT for more efficient trips (de Abreu e Silva & Melo, 2018).

Business Location Choice

How does the rise of telecommuting affect where a business decides to locate? Much of the research focuses less explicitly on this and more on the relative distance between a business and where their employees choose to live, with the business location being stationary. Although the research is limited on business location choice, some conclusions can be reached. The research suggests that with increasing telecommuting, businesses in areas with high land values may downsize and/or decentralize with additional satellite offices or simply relocate to areas with lower costs.

There is potential for businesses to rethink their location choice given the rise of telecommuting. Some firms can expand with satellite offices (i.e., center-based telecommuting) outside the urban center to reduce their operation costs (Tayyaran & Khan, 2003). This shift may cause jurisdictions within a metropolitan region to compete to attract business. One model finds that firms encourage telecommuting to downsize their physical office space to reduce costs (Rhee, 2008). If businesses are to promote home-based telecommuting, some of the costs associated with maintaining an employee becomes the employee's responsibility such as office furniture and utilities (e.g., internet, water, and electricity). Another consideration is that if home-based telecommuting is a viable option, then the labor pool vastly increases allowing firms to hire cheaper talent without physically relocating the firm.

Although telecommuting may open up new possibilities for business location and operation, its impacts are likely to vary by industry or business type. One benefit for businesses concentrating in the central business district is to take advantage of agglomeration economies, which is when productivity increases from the exchange of information and marketing of products through personal interactions between firms (Safirova, 2002). This advantage may still be vital for some types of businesses even with the increased feasibility of telecommuting, while location is not as crucial for other businesses. Advanced information and communications technologies have long been viewed as an enabler for businesses to move to the urban periphery to take advantage of less expensive land and to follow their consumers and employees (Tayyaran & Khan, 2003), but the degree of business clustering has not dramatically diminished in some sectors.

Business location choice may also be shaped by government actions. With the rise of telecommuting, governments are thinking about what possibilities may exist for the future of office locations. For example, with the increased mobility gained from telecommuting, governments can advocate for center-based telecommuting to physically move business establishments to cooler climates in the summer as part of an effort to reduce energy consumption or to revitalize tourist areas facing economic decline in the off-season (Muto et al., 2019). If businesses choose to leave the central business district, governments can reclaim office areas for alternative uses that bring increased economic and social benefits such as housing or walkable mixed-use development (Zhen & Wei, 2008). In already suburbanized communities, planners can ensure that business locates to places where key transportation infrastructure and routes intersect (Tayyaran et al., 2003).

As mentioned above, not much scholarly attention has been paid to the implications of telecommuting for business location choice, so little is known about how telecommuting would reshape the location of business activities. There are additional considerations about telecommuting and business location decisions that need further exploration. For example, telecommuting raises questions about the distribution of self-employed home-based telecommuters who either work at home or in shared office spaces. How should these independent contractors be counted and categorized in studies? Telecommuting may also have long-term consequences on where businesses locate, especially given the accelerated adoption of telecommuting from the COVID-19 pandemic. It is unclear what will happen to establishments such as restaurants that cater to downtown businesses and their employees, if those businesses downsize or relocate as a result of adopting telecommuting policies. Where households and businesses choose to locate and whether to adopt telecommuting are all interconnected, but not much is known about the evolving connection between them

Land Use and Urban Spatial Structure

The changing locations of households and businesses can lead to a gradual (or even radical) shift in the way an entire city or metropolitan region is spatially organized. Researchers have paid attention to how the rise of telecommuting can influence regional land use patterns and urban/metropolitan spatial structure, looking beyond the effect on individual households or businesses. Although some studies separate these small scale and large scale effects, researchers also note that individual location decisions have a cumulative impact on urban form (Kim, 2016).

At first glance, one could imagine that telecommuting may lead to greater decentralization (or sprawl), and it is not difficult to come across anecdotal evidence of such moves (Greiff & Sen, 2020). However, as discussed below the impacts of telecommuting can be much more complex.

Central Business District

There is speculation that some businesses based in the central business district (CBD) may physically downsize office space or close as telecommuting becomes more prevalent. This speculation is based on research finding that employees who have to pay for parking and those whose commutes involve more stressful roadway driving conditions—both indicative of CBD workers—are more likely to telecommute (Sener & Bhat, 2011). Such downsizing or business closures may impact small businesses aimed at serving downtown office workers. A recent study shows that "accommodation and food services, in particular, are negatively impacted by reduced foot traffic" (Dalton et al., 2022, p. 3). However, there may also be opportunities to revitalize CBDs with more walkable mixed-use housing with small businesses now catering to these new residents.

Telecommuting growth, however, does not necessarily mean that businesses will move away from the CBD to the periphery. The CBD is still an important hub given the benefits of agglomeration economies, and not all sectors in the CBD can fully take advantage of telecommuting because of the in-person nature of some occupations. CBDs are often walkable hubs for music and the arts, gathering places for sports, and other leisurely attractions that draw visitors and potential new residents. While a telecommuter could move away from the CBD to a suburban neighborhood with better school districts for their children, others could move toward the city center away from a suburban office (Zhu, 2013). Given the unique amenities available in the CBD and their appeal to diverse population groups, planning for mixed-use development with housing in CBDs may still be important.

Suburban Multinucleated Centers

The proliferation of telecommuting can also transform the suburban landscape. One possibility is the emergence (or reinforcement) of a multinucleated structure, which refers to "a structure where a number of

urban satellite nodes, containing mixed business and residential land uses, are located at some distance from the central core and along radial transportation corridors" (Tayyaran & Khan, 2003, p. 96). As mentioned in the introduction and Appendix A describing the various categories of telecommuting, home-based telecommuting is not the only possible unconventional work-home arrangement. Center-based and nomad-based telecommuting are other possibilities, where some suburban locations may undergo a transformation with the increasing demand for satellite office spaces and other infrastructure.

Given this possibility, traffic between suburban nodes should be considered when planning alternative transportation (Tayyaran & Khan, 2003). Increasingly multinucleated metropolitan regions are not necessarily negative as they could provide an opportunity to increase transportation efficiency and improve air quality (Tayyaran & Khan, 2003). For instance, if suburbs become the one stop shop for all activities, then the need to go to traditional CBDs can decrease (Kim, 2016). However, it is not yet clear how such transformation needs to be managed through land use planning, while one could consider containment policies, such as urban growth boundaries, or repurposing single family zoned land uses to denser housing types to close the distance between commercial and residential land uses. Furthermore, pursuing a one-size-fits-all approach is unlikely to be effective. Studies show that urbanized residents tend to have shorter trip distances than suburban residents, but living in a larger metropolitan region can result in longer non-work trips (Zhu, 2012). Creating suburban centers that have more urban characteristics can yield the benefits of shorter trips, but at the expense of more trips, particularly in smaller metropolitan regions (Zhu et al., 2018).

Exurban Growth and Further Sprawl

Pre-pandemic, telecommuters were less likely to live in rural areas (Ellen & Hempstead, 2002) and more likely to live in suburban areas (Caulfield, 2015; Kim et al., 2012). Using 2009 data, one study suggests that telecommuting likely increases the larger the employee's metropolitan statistical area (Jin & Wu, 2011), corroborating the notion that telecommuters did not generally live in rural areas. However, since the COVID-19 pandemic, there has been a noticeable trend toward telecommuters leaving the city for more remote locations. This tendency to relocate out of cities is often exemplified by the emergence of "Zoom Towns" coined by real estate journalists around August 2020, five months after the first shelter-in-place policies began in the United States. The term is used to describe the uptick in people moving to smaller, more rural vacation towns due to the proliferation of telecommuting due to the pandemic (Greiff & Sen, 2020).

This trend has raised concerns about telecommuting-initiated edge development and newly formed sprawl. At the time of this report, post-pandemic findings on household location choice are still inconclusive. It has been suggested that COVID-19 led to a spatial redistribution of economic activity, but did not result in widespread worker relocation to more distant rural areas (Denham, 2021). A large proportion of any future household relocations will likely take place within the economic sphere of a metropolis, although this could mean the growth of newly annexed jurisdictions at the urban edge (Denham, 2021). A related issue is how this process, if not guided properly, will contribute to residential segregation. This issue deserves more attention particularly

because not everyone can take advantage of telecommuting as discussed further in the Equity and Justice section below.

Engaging with Land Use Transformation in the Telecommuting Age

Across the continuum of central-suburban-remote locations, the increasing popularity of telecommuting means planners need to reflect on the way they allocate land resources for various purposes. For instance, one can begin to speculate how the growth of telecommuting may impact commercial land uses. Research suggests that with telecommuting, voluntary travel may increase and spread out spatially and temporally since workers are not tied to a fixed commuting schedule. Whether such trips are close to home or further than when telecommuters were non-telecommuters is unclear, but promoting mixed-use land uses where telecommuters can walk to non-work activities from their home can make a difference.

Studies have also investigated whether telecommuters are also more likely to adopt other teleactivities compared to non-telecommuters (Andreev et al., 2010; Sener & Reeder, 2012). Telecommuters are believed to be more likely to adopt virtual services as they are more familiar with advanced information and communications technologies. However, opposing opinions exist. Rather than adopting teleshopping, teleleisure, or telebanking, telecommuters may elect to do activities in person to increase face-to-face communication or to simply get out of the house. If teleactivities do proliferate from increased telecommuting, it may be necessary to consider designating loading zones and package delivery areas for residential neighborhoods. Additionally, it may be possible to reduce parking requirements in business districts.

Also understudied is the impact of and opportunities for telecommuters to work in non-traditional office spaces such as at home or a third place. Residential zones may need to install infrastructure to accommodate better broadband. Refurbished and new construction homes may need to incorporate a dedicated home office space in both single-family homes and multifamily structures. Third places, such as coffee shops, may experience more traffic affecting parking demand or off-peak transit demand possibly warranting revised traffic studies. New issues of land use planning may also arise as telecommuting reshapes the way in which building spaces are used for housing and economic development. For example, there is a new trend toward telecommuters renting out vacation homes alone or in groups to enjoy a variety of unique work environments (Airbnb, 2022). One such documented public-private partnership involves the company Airbnb which collaborates with government agencies to promote remote work in their locality to boost tourism and tax dollars. In return, the company generates revenue through the promotion and use of their platform for renting out homestays (Airbnb, 2022).

Environmental Sustainability

As discussed earlier, telecommuting can significantly modify where people live/work, how they travel, and in what ways our cities/regions are spatially organized. All these possibilities suggest that the rise of telecommuting can have significant implications for environmental sustainability. In fact, telecommuting has often been seen as a promising means to improve air quality and fight climate change by reducing per capita VMT. However, planning scholars and practitioners are concerned that if telecommuting induces further sprawl, a rebound effect could occur canceling out these environmental benefits or even worsening the environment.

A great deal of scholarly attention has been paid to whether telecommuting is likely to promote or threaten environmental sustainability. As described below, researchers have examined this important issue with a focus on how telecommuting could modify (1) commuting patterns, (2) non-work and off-peak trips, and (3) energy uses or environmental impacts that are not directly related to transportation.

Commuting Patterns

How can telecommuting affect commuting patterns and thereby advance environmental sustainability? As described in the Location Choice section, the research finds that telecommuters often choose to live further from the office than non-telecommuters. One may ask, "what is the issue with a telecommuter moving further from the office if they work from home?" This takes us back to the challenge of defining telecommuting. One key assumption made in the research is that telecommuting may be hybrid; even for telecommuters in-person work is necessary or desired one or more times per week and during those days the telecommuter physically comes into the office home further from the office. The question then becomes whether the increased distance traveled on regular commute days cancels out the environmental benefits gained from not having to commute in-person on other days. Intriguingly, this concern could be a non-issue if home-based telecommuting is full-time (Jin & Wu, 2011), while full-time telecommuting can still induce more energy consumption due to non-work travel or other reasons.

The reported research findings vary and may contradict each other depending on the frequency and type of telecommuting studied. In an attempt to find the optimal telecommuting arrangement which reduces the most greenhouse gas emissions, one study provided a California-based simulation to estimate the different CO_2 emission levels for various commute distances and telecommuting frequency combinations (Kitou & Horvath, 2006). The simulation results show that increasing telecommuting frequency by a day a week brings more benefits than reducing the normal commute by up to five miles one-way. Savings from moving more than five miles closer to work would not be entirely offset by the additional telecommuting day (Kitou & Horvath, 2006). For occasional telecommuters, a study using 2009 data finds that telecommuters who work from home at least once per week (but not full-time) travel 45 vehicle miles more than a non-telecommuter which translates to

adding over 8.8 million more cars on the road a year (Zhu & Mason, 2014). Another complication is that physically commuting to a satellite office is often considered a telecommute. This means that a study can have a "telecommuter" making the same number of commute trips per week as a regular commuter. Be that as it may, a "telecommuter" commuting to a satellite office is likely to make a shorter trip versus commuting to the main office. One study using data for a sample of telecommuters in California finds that center-based telecommuting decreased VMT significantly (Mokhtarian & Varma, 1998). An earlier study using data from the Puget Sound Telecommuting Demonstration Project also suggests that center-based telecommuting can contribute to reducing VMT (Henderson & Mokhtarian, 1996).

It is important to note, however, that telecommuting can be seen as more promising when consideration is given to a few of the other possibilities it can offer. First, commute patterns for telecommuters who do occasionally commute to the main office or an alternative work center may spread out from the traditional AM and PM peak periods. Rather than commuting between 5am-7am, these telecommuters tend to commute between 8am and 3pm according to one study (Yum, 2021). This is expected given that telecommuting also includes part-day telecommuters who may commute outside the traditional peak hours to reduce time spent in traffic. This change in travel patterns can contribute to alleviating congestion and thus reducing greenhouse gas emissions.

Second, even if telecommuting is not full-time home-based and the telecommuter physically commutes in-person one or more times per week, we cannot assume that their mode choice remains the same or is always in a single occupancy vehicle. One UK study finds that on in-person commute days, telecommuters are twice as likely to travel to London by heavy rail and thus not contributing to VMT (Budnitz et al., 2020). Another study in the Twin Cities region of Minneapolis and St. Paul finds that for commute and leisure trips, telecommuters are more likely to use modes other than single occupancy driving (Yum, 2021). One study in the U.S. using 2009 national data finds that more than 22 percent of commuter rail users work from home at least some of the time (Jin & Wu, 2011). It is not always clear whether telecommuting causes drivers to use alternative transportation or telecommuters were already using alternative transportation or had other reasons which led to the use of these alternative modes (Chakrabarti, 2018).

Finally, another factor to consider is changes in business trips. Some studies have attempted to model business trips by air to visit clients or another branch office or attending industry conferences that can be replaced by virtual meetings given that air travel generates a large amount of pollution (Kitou & Horvath, 2006).

Voluntary and Off-Peak Trips

When it comes to non-work based travel, telecommuting has often been viewed as a challenge rather than an opportunity. Telecommuting might lead to an increase in non-work trips and trip lengths due to the increased flexibility telecommuters can have (Cerqueira et al., 2020). This flexibility includes the ability to make quick trips close to the home, increase their transportation budget, and the increased time they have available from not commuting. If the goal of telecommuting is to reduce air pollution or traffic congestion, then the higher

number of trips overall are a concern as they can offset the VMT improvements gained from fewer commuting trips.

However, one study finds that the increase in non-work trips when comparing telecommuters and non-telecommuters may be misleading as some previous studies do not disaggregate chained trips from a commute between work and home (Cerqueira et al., 2020). This means that stops made on the way to work or on the way from work to home such as the grocery store, gym, or other non-work activity are not counted as a separate trip (Cerqueira et al., 2020). This failure to consider voluntary trip chaining leads to an apparent increase in overall travel due to the number of off-peak non-work trips by telecommuters. One study finds telecommuters tend to make shopping trips between 7am to 11 am as opposed to traditional commuters who generally shop between 12pm and 6pm (Yum, 2021). An additional caveat to consider is that the socioeconomic characteristics of a household, space-time constraints, and long working hours can influence travel patterns for non-work trips. For example, having children can increase the average number of non-work trips showing that not all telecommuters will have the same type of travel behavior (Cerqueira et al., 2020). Such a caveat further suggests the complexity behind voluntary trip behavior.

Additionally, one cannot automatically assume that non-work and off-peak trips are taken by a single occupancy vehicle since they are likely to be less time constrained than work trips. Contrary to some U.S. and China based studies, a European study finds that their more transit-oriented land use promotes using alternative modes for voluntary trips (Budnitz et al., 2020). Moreover, some studies find that the time saved from not having to commute to the office can lead to choosing alternative modes of transportation which would normally take longer than traveling by single occupancy vehicle. Other studies speculate that telecommuters choose more public modes of travel to increase human interaction and get out of the house (Yum, 2021). It is further argued that telecommuting can enable sustainable and resilient communities as long as planning policies actively work to achieve such a future (Budnitz et al., 2020). For example, one study finds that persons who telecommute four or more times per month take15 percent more walk trips per week and are 44 percent more likely to have 30 minutes of physical activity per day (Chakrabarti, 2018).

Researchers often link telecommuting with teleactivities as telecommuters may be more likely to use teleservices given their greater knowledge of information and communication technology (Mokhtarian et al., 2004). Conversely, one can also argue that telecommuters will want to take more non-work trips in person to get out of the house and enjoy face-to-face interactions. The environmental implications of telecommuters also engaging in more teleactivities may reduce the number of trips taken. Still, the environmental impacts of increased app-based delivery services are still uncertain at this time, especially related to telecommuter adoption of teleactivities.

Energy Use

Attention has also been paid to the broader environmental implications of telecommuting, with a focus on its impact on energy consumption (beyond its effects on commuting or non-commuting trips), and the research is

mixed as to whether (and to what extent) telecommuting increases or decreases energy use. One study argues that telecommuting can reduce energy use given that transport has larger energy requirements than other common activities (Bieser & Hilty, 2020). It is challenging, however, to precisely measure the impacts of telecommuting. A few of the telecommuting studies build simulations to quantify energy use based on the amount of CO_2 emissions. While energy use is typically described as an aggregation of office building energy use, transport energy use, and household energy use, how telecommuting would affect each of these components depends on geography, weather, and household characteristics. For example, some studies argue that telecommuting will increase household energy use since telecommuters will have to heat their home when they are there working (Cerqueira et al., 2020; Kitou & Horvath, 2006). However, if other household members were already at home with the heat on during work hours, then energy use would not necessarily be increased. Additionally, many assumptions go into simulations such as which part of the house the home office is located, what type of lightbulbs are used, and what type of vehicle the telecommuter uses.

It is also possible to anticipate changes in indirect energy requirements, such as the production of certain goods or services, as a result of telecommuting. For instance, if telecommuting leads to fewer vehicle purchases this can also contribute to reduced energy use in vehicle manufacturing and delivery, as well as end-of-life disposal (Kitou & Horvath, 2006).

There are other aspects that planners should consider in the future regarding the nexus between telecommuting and energy use. Given that there are companies that have shifted to majority home-based telecommuting since the COVID-19 pandemic, office spaces may be inefficiently used given that fewer employees are physically present compared to before the pandemic. It is also unclear what changes in energy use have resulted from telecommuting and if it disproportionately affects certain communities.

Equity and Justice

Even if telecommuting can contribute to reducing VMT or aggregate energy use, it does not necessarily benefit all workers and communities. In fact, the impacts of telecommuting have not been uniform inf different areas. Furthermore, since the rise of telecommuting can affect not only telecommuters but also those who do not telework (through changes in urban/metropolitan spatial structure, transportation networks, or even public policy and planning initiatives), its implications for equity and environmental justice deserve special attention.

Who Telecommutes and Who Does Not?

Research into who telecommutes (and who does not) has shown that the proliferation of telecommuting is uneven across various socioeconomic categories. According to these studies, men are more likely to telecommute than women (Shabanpour et al., 2018) as are those over the age of 30 (Sener & Bhat, 2011), with higher education (Sener & Bhat, 2011), and larger income (Mannering & Mokhtarian, 1995; Sener & Bhat, 2011). One could interpret these findings as an indication that older men, graduate degree holders, and higher income persons have a higher rank in the office with better bargaining power to negotiate for a telecommuting arrangement. Conversely, one study finds managers of companies are less likely to telecommute (Shabanpour et al., 2018).

Studies have also reported that workers in jobs that more clearly require face-to-face work such as those in the manufacturing, transportation, retail, and other industries (MATRE) category are less likely to telecommute (Shabanpour et al., 2018). Full-time employees (working 30 or more hours per week) are more likely to telecommute than part-time workers (Sener & Bhat, 2011). Work flexibility also affects the likelihood to telecommute. For example, employees in real estate sectors are much more likely to telecommute compared to those with inflexible jobs in manufacturing, transportation, and retail industries (Sener & Bhat, 2011). Those in the service industry sometimes labeled as white collar workers, creative workers, or knowledge workers tend to telecommute at higher rates (Denham, 2021; Sener & Bhat, 2011).

It should be noted, however, that who is more likely to telecommute can vary by location, and planners should consider this rather than assume the demographic characteristics of telecommuters identified in the research literature will fully apply to their locality. In addition, it is important to be aware of those in sensitive situations who have hidden their alternative work arrangements from data collectors because they do not wish to report their income, their documented status, lack an appropriate business license, are in violation of local zoning ordinances, or cannot work within certain jurisdictions (Gurstein, 1996). In the age of telecommuting, this may include online gig workers or freelancers providing digital services such as copywriting, art for businesses, or ad voiceovers. Alternative work may also include selling homemade foods on online forums that are picked-up or delivered.

The number of vehicles in a household may also have an impact on telecommuting behavior, but the research is equivocal about the relationship. Some studies suggest that those with more vehicles are less likely to telecommute, but other studies find the opposite (Sener & Bhat, 2011; Shabanpour et al., 2018). Those that use non-car modes of travel are more likely to telecommute (Sener & Bhat, 2011). Some studies note that households with children, particularly 15 years or younger, are more likely to telecommute than those with no children (Sener & Bhat, 2011; Zhu, 2013). Interestingly, although the presence of children affects decisions to telecommute, their presence does not similarly affect telecommuting frequency (Sener & Bhat, 2011). Less attention has been paid to the effect the presence of dependents such as older adults or those who need assistance with day-to-day activities has on telecommuting.

At the individual and household level, this uneven distribution of telecommuters can mean lower income workers with lower education levels, lower flexibility, and working multiple jobs are less likely to take advantage of telecommuting. Telecommuting can reduce travel time, transportation costs, enable workers to move to places with more affordable housing, or use any money saved to move to neighborhoods with better schools and greater social capital. Telecommuting can also lower care costs for children and other dependents such as aging and disabled household members (Dardas et al., 2020). The COVID-19 pandemic has made it evident that telecommuting can create more economically resilient households in addition to increased health and safety for families and other loved ones. COVID-19 is also not the only "crisis" where telecommuting can provide economic resilience in a household. Post-disaster periods such as after a hurricane can benefit from telecommuting given the flexibility of choosing where to report to work (Kontou et al., 2017). However, the uneven distribution of teleworking shows that this flexibility is likely unavailable for some household groups.

While it is widely believed that telecommuting can improve the quality of life for the aforementioned reasons, telecommuting may not always lead to a better quality of life, which may be affected by individual and household values (Hubers et al., 2011). For example, a home-based telecommuting woman in a two-worker household that values traditional gendered domestic responsibilities could experience reduced work-life balance (Hubers et al., 2011). Telecommuting policies should include coping strategies for both paid and unpaid responsibilities by, for example, making subsidies availability for childcare (Hubers et al., 2011). Further, telecommuting policies should consider the diverse needs of various groups of the population (Hubers et al., 2011).

Broader Distributional Consequences

As noted above, the consequences of telecommuting are not limited to what happens to those who are able to take advantage of telecommuting. The (uneven) rise of telecommuting can have broader consequences on individuals and their communities, as it can impact urban spatial structure and the way our cities/regions work. The rise of telecommuting may also support or conflict with our ongoing efforts to build more inclusive communities and promote environmental justice.

As telecommuting continues to grow, more attention needs to be paid to digital divides in information and communication technology. Both at the household and neighborhood level, internet quality can affect groups differently (Budnitz & Tranos, 2021). For example, about 15 percent of households in the Southern California region "do not have access to adequate internet speeds or no internet access [and] these households are disproportionately located in underserved and urban communities and rural communities" (SCAG, n.d.).

Also, "broadband policies cannot improve the economic resilience of places where the industrial structure does not align with occupations that incorporate the digital skills and capabilities to work from home. Such places instead experienced higher proportions of their labor force being placed on furlough [during the COVID-19 pandemic]" (p.15, Budnitz & Tranos, 2021). Finding avenues to improve the ability to telecommute for jobs that do not align with the capacity to work from home could help close the gap on that digital divide. For example, using federal grant funds in 2022, the County of San Diego's libraries established a program which allows patrons to borrow a laptop and hot spot device on an annual basis (Land Use and Environment Group County of San Diego, 2023). In addition, the County of San Diego is collaborating with the regional planning authority SANDAG, utilities, tribal governments, internet service providers, and the state transportation department Caltrans to implement internet infrastructure in unincorporated areas during existing Caltrans projects that already require digging. Collaboration also takes place between SANDAG and the Southern California Association of Governments in seeking partnerships to broadly provide more affordable and reliable broadband services (SCAG, n.d.).

It appears however that telecommuting research has not fully addressed the broader distributional consequences, including how it could mitigate or amplify disparities between communities. It remains unclear how the expansion of telecommuting, if guided in a certain way, would change the distribution of environmental burdens and amenities. There is more to be explored regarding a potential link between areas with a high number of low-income employees and their disproportionate exposure to air pollution due to the uneven distribution of telecommuting. The emergence of new forms of development, such as the so-called Zoom Towns, and their contribution to residential segregation and possible gentrification are also worthy of more investigation.

Conclusions and Implications for Planning

As explored in the previous sections, decades of research have examined telecommuting and enabled us to contemplate what can potentially happen in the wake of the decline in conventional forms of work-home arrangements. Yet in many respects, the research is inconclusive on how telecommuting will reshape the workings of our cities/regions. While this can be attributed to some extent to the variations in the definition (or characterization) of telecommuting, the mixed findings may also indicate the open and context-specific nature of the transformation induced by the proliferation of telecommuting. In this sense, what confronts planners is not just a task of responding to the new reality but rather a demand for shaping the future in a way that better reflects their communities' goals and priorities.

What does this mean for California planning? What lessons can be drawn from the inconclusive nature of the research findings for California planners?

It is important to recognize the breadth of the effect telecommuting can have, directly or indirectly. Although the current research is not unequivocal, the impacts of telecommuting are not limited to changes in travel demand. There is little disagreement that telecommuting can alter the demand for housing, land use, community development, environmental management, and more. Given the interdependence of the various planning fields, systematic coordination will be increasingly needed to better deal with the rise of telecommuting in California and beyond.

The broad relevance of telecommuting to all fields of planning may also encourage planners to explore ways to leverage this opportunity at various levels and/or better align their ongoing projects/initiatives with the changing environment. Telecommuting has the potential to increase work-life balance and be a tool for upward mobility by increasing access to opportunities which may not have been possible because of prohibitive transportation and housing costs or inflexible arrangements for care of dependents in a household. As described previously, these opportunities to telecommute are uneven across the population, and the limited access to telecommuting is often caused by employer restrictions and lack of telecommunications infrastructure. In February of 2022, California state legislators began debating a bill that would promote telecommuting among employers through tax reductions of $1,000 per verified telecommuting employee of 25 hours or more per week using funds from the Greenhouse Gas Reduction Fund (California Legislature, 2022). The State of California's Public Utilities Commission receives federal funding to manage grant programs that reimburses local governments and Tribal entities that complete last-mile broadband infrastructure deployments and promote digital literacy programs (California Public Utilities Commission (CPUC), 2022).

Through the continuation of design innovations and spatially-targeted interventions, planners can also make a meaningful difference in realizing the potential contribution of telecommuting to travel demand management, VMT reduction, and environmental sustainability. Programs such as Complete Streets and Vision Zero which aim to improve safety and accessibility through traffic calming and alternative transportation infrastructure

improvements can better incentivize walking and bicycling. For long distance commuters such as from suburban locations to the CBD or another suburban office node, using First/Last Mile transportation planning strategies such as on-demand shuttles from home to commuter train stations can make it easier for commuters to use alternative modes. As noted earlier, the research shows that if the neighborhood has mixed-use, pedestrian-friendly attributes with sustainable commute modes, telecommuters frequently elect to use alternative transportation modes for both voluntary trips and work trips during in-person commute days. Therefore, continuing to promote transit-oriented development and sustainable modes of transportation is still beneficial as telecommuting proliferates. Much of the concern in the research regarding increased commute distance and VMT can also be mitigated through these initiatives particularly if land use and transportation investment decisions are well coordinated along with other efforts to better guide hybrid and part-day telecommuting for congestion reduction.

Land use decisions also need to reflect community needs and economic development strategies. Telecommuting may reduce the need for large office spaces in the CBD and elsewhere, posing a significant challenge to small businesses catering to these office workers. Quickly repurposing these vacant offices for uses such as housing could rebuild a new client base for these small businesses. The emergence of new activity centers along with center-based or nomad-based telecommuting will demand different land use planning strategies in other locations. What is required is not a one-size-fits-all approach but context-dependent coordination of land use and community/economic development.

Housing should not be excluded from these coordination efforts. In 2019, nearly 40 percent of California households were found to be housing cost burdened with households dedicating at least 30 percent of their income to housing (Garcia et al., 2022). Telecommuting presents an opportunity to reduce these financial burdens by allowing households to save their transportation costs or relocate further from the office to more affordable housing locations (Taylor, 2015). Studies show, however, that telecommuters desire more housing space particularly in the form of a single family house rather than a compact housing type (Qin et al., 2021). In other words, making housing more affordable will remain challenging and require major efforts in the age of telecommuting. One promising strategy is repurposing vacant offices for housing as mentioned above. Government agencies across the nation are already looking into incentivizing developers through tax credits to repurpose such underutilized offices (Witthaus, 2022). Planners can also increase mixed-use housing supply in or near newly emerging activity centers. Amenities such as better internet infrastructure in these working hubs may help address household equity issues with internet connectivity and other telecommuting infrastructure challenges. Better internet infrastructure can also be crowdfunded by the neighborhood. For example, by pricing street parking, the funds can be repurposed by a neighborhood group or local government for free public Wi-Fi (Shoup, 2018). A combination of such planning measures may further increase household location choice for a more environmentally sustainable mid to high density lifestyle rather than inducing further sprawl in California.

In addition to promoting the benefits of telecommuter access through increased telecommuting infrastructure and policies that can prevent sprawl, it is also important to consider, on a more macro scale, the possibility of coordination between municipalities. The rise of telecommuting can lead to increasing inequality and

segregation between cities where residents can easily take advantage of digital resources and those where they cannot. With telecommuters relocating either to the urban periphery, from suburb-to-suburb, or possibly moving toward central locations, different groups of people may be populating one area and leaving another. Such migration could take place in a way that increases inequality because not everyone can take advantage of telecommuting. This long-term shift is something planners may need to consider in concert with the impacts on vehicle miles traveled or energy consumption. Given that this relocation trend was already occurring even before the COVID-19 pandemic, planners need to come together and collaborate on how to monitor or guide the regional restructuring process to build more inclusive communities and reduce disparities between municipalities.

It is our hope that all these planning efforts will be continuously informed by further research on telecommuting and its evolution. Employers may become more comfortable with a work-from-home arrangement over time leading to the possibility of full-time home-based telecommuting. Much has also changed since the COVID-19 pandemic regarding society's understanding of what telecommuting is. During the strictest phase of the pandemic's lockdown, full-time home-based telecommuting was often the only option. Information and communication technology has rapidly progressed, and many businesses and agencies have upgraded their digital infrastructure out of necessity. Human behavior may have also changed as a result of the pandemic where people may or may not want to work in-person either out of a missing sense of community during isolation or in increased concern for their individual and household health. Early in the pandemic, it was feared that dense urban areas such as New York City would face a more permanent exodus due to the pandemic (Office of New York City Comptroller Scott M. Stringer, 2021). However, toward the tail-end of the pandemic in August 2022, rents were hitting record highs with demand outweighing supply (Champelli, 2022). More is yet to be known about these rapidly evolving changes and longer-term consequences of telecommuting.

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Appendix A – Varying Categorizations of Telecommuting

How researchers categorize the different types of telecommuting may impact the research results. The definitions and specific terms used by researchers when surveying people can also affect the data used for empirical studies (Pratt, 2000). The following is not an attempt at standardization. Rather, we are documenting and trying to make sense of the various categorizations we have encountered while reviewing the existing research.

One way to categorize telecommuters is spatially. There are three key spatial types of telecommuting. First, is center-based telecommuting (Bieser et al., 2021; Dissanayake, 2008; Dissanayake & Morikawa, 2008; Stanek & Mokhtarian, 1998). Workers telecommute from company satellite offices in-person. Sometimes it is a shared office space with multiple businesses under one building. Second, is home-based telecommuting (Bieser et al., 2021; Cerqueira et al., 2020; Dissanayake & Morikawa, 2008; Kim, 2017; Rhee, 2008; Stanek & Mokhtarian, 1998). This is when workers telecommute from their home. It is important to note there are two types of home-based telecommuting. There are self-employed home-based telecommuters and telecommuters who are employees of a company working at home. The former workers are occasionally not recognized as telecommuters in academic journal articles because they do not have an alternative work location to commute to (Asgari & Jin, 2017). However, this can be misleading because these workers may be able to choose and in-person job that is in-person if their self-employed home-based job fails. Third, there are nomadic workers (Benita, 2021). These workers work from unrelated locations such as coffee shops, libraries, and recreational or sports facilities. This is an important distinction from center-based telecommuting as nomad-based telecommuters may be commuting to places within different land uses compared to center-based telecommuters.

Telecommuters can also be categorized temporally. There are three key time-based types of telecommuting. First, is full-time telecommuting. This telecommuter never physically goes to the main. Second, is part-time telecommuting (Elldér, 2020). The telecommuter will telecommute for the full workday, but not all days of the work week. Third, is part-day telecommuting (Asgari & Jin, 2017; Elldér, 2020). This telecommuter teleworks and goes into the main office on the same workday. Sometimes this is a strategy to spread out peak hour traffic. Also note that these distinctions are separate from full-time and part-time employment. There are also infrequent telecommuters and never-telecommuters who can be labeled as non-telecommuters. Infrequent telecommuters are those who telecommute, for example, once a month. Studies may categorize such telecommuters as non-telecommuters, then omit them from datasets because they may not have a sizable effect on commute trip or residential location choice (Zhu, 2013).

As one may notice, these categories can be mixed and matched creating different scenarios of telecommuting. For example, there can be a center-based telecommuter, but a study may categorize them as a full-time

telecommuter. One may think this full-time telecommuter does not physically go to a worksite, but they are indeed commuting to an office in-person that is not at home depending on the definition. Put simply, one can leave the home and commute while still holding the telecommuter label. Given the inconsistencies with the telecommuting label, future studies may want to examine the proliferation of telecommuting across types with careful emphasis on each definition.

Appendix B – Directional Relationship and Causality

Some studies note that often the cause for households changing their residence locations is difficult to pinpoint because people move for various reasons besides ease of commuting, and thus, whether telecommuting should be "blamed" for moving further from work (Mokhtarian et al., 2004). The literature suggests that jobs that allow telecommuting can be concentrated in some locations (Kim et al., 2012), and challenges exist in determining whether telecommuting begins before or after household relocation (Ory & Mokhtarian, 2006). Studies also show that the relationship between telecommuting and household location choice is not one-way. It goes in both directions implying that telecommuting can determine household location choice and, at the same time, household location choice can also determine telecommuting (Kim, 2016). Self-selection bias may also pose a challenge to understanding the behavioral patterns of telecommuters. For example, in regard to whether telecommuting increases physical activity and active transportation mode choice, there can be factors outside of the study which influences these decisions. What this means is that an individual who values an active lifestyle may have consciously selected a telecommuting job so they can pursue said lifestyle (p.31, Chakrabarti, 2018).