SJSU SAN JOSÉ STATE UNIVERSITY

MTI MINETA TRANSPORTATION INSTITUTE

"TELE-commuting" during the COVID-19 Pandemic and Beyond: Unveiling State-wide Patterns and Trends of Telecommuting in Relation to Transportation, Employment, Land Use, and Emissions in California

Tianjun Lu, Ph.D.
Fynnwin Prager, Ph.D.
Jian-yu Ke, Ph.D.
Jose N. Martinez, Ph.D.

CSUTC California State University Transportation Consortium

CSUDH CALIFORNIA STATE UNIVERSITY DOMINGUEZ HILLS

CSU TRANSPORTATION CONSORTIUM

transweb.sjsu.edu/csutc

Mineta Transportation Institute

Founded in 1991, the Mineta Transportation Institute (MTI), an organized research and training unit in partnership with the Lucas College and Graduate School of Business at San José State University (SJSU), increases mobility for all by improving the safety, efficiency, accessibility, and convenience of our nation's transportation system. Through research, education, workforce development, and technology transfer, we help create a connected world. MTI leads the Mineta Consortium for Transportation Mobility (MCTM) funded by the U.S. Department of Transportation and the California State University Transportation Consortium (CSUTC) funded by the State of California through Senate Bill 1. MTI focuses on three primary responsibilities:

Research

MTI conducts multi-disciplinary research focused on surface transportation that contributes to effective decision making. Research areas include: active transportation; planning and policy; security and counterterrorism; sustainable transportation and land use; transit and passenger rail; transportation engineering; transportation finance; transportation technology; and workforce and labor. MTI research publications undergo expert peer review to ensure the quality of the research.

Education and Workforce

To ensure the efficient movement of people and products, we must prepare a new cohort of transportation professionals who are ready to lead a more diverse, inclusive, and equitable transportation industry. To help achieve this, MTI sponsors a suite of workforce development and education opportunities. The Institute supports educational programs offered by the Lucas Graduate School of Business: a Master of Science in Transportation Management, plus graduate certificates that include High-Speed and Intercity Rail Management and Transportation Security Management. These flexible programs offer live online classes so that working transportation professionals can pursue an advanced degree regardless of their location.

Information and Technology Transfer

MTI utilizes a diverse array of dissemination methods and media to ensure research results reach those responsible for managing change. These methods include publication, seminars, workshops, websites, social media, webinars, and other technology transfer mechanisms. Additionally, MTI promotes the availability of completed research to professional organizations and works to integrate the research findings into the graduate education program. MTI's extensive collection of transportation-related publications is integrated into San José State University's world-class Martin Luther King, Jr. Library.

Report 22-38

"TELE-commuting" During the COVID-19 Pandemic and Beyond: Unveiling State-wide Patterns and Trends of Telecommuting in Relation to Transportation, Employment, Land Use, and Emissions in California

Tianjun Lu, Ph.D.

Jian-yu Ke, Ph.D.

Fynnwin Prager, Ph.D.

Jose N. Martinez, Ph.D.

August 2022

A publication of the
Mineta Transportation Institute
Created by Congress in 1991

College of Business
San José State University
San José, CA 95192-0219

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. 22-38	**2. Government Accession No.**	**3. Recipient's Catalog No.**	
4. Title and Subtitle "TELE-commuting" During the COVID-19 Pandemic and Beyond: Unveiling State-wide Patterns and Trends of Telecommuting in Relation to Transportation, Employment, Land Use, and Emissions in California		**5. Report Date** August 2022 **6. Performing Organization Code**	
7. Authors Tianjun Lu, Ph.D. Jian-yu Ke, Ph.D. Fynnwin Prager, Ph.D. Jose N. Martinez, Ph.D.		**8. Performing Organization Report** CA-MTI-2147	
9. Performing Organization Name and Address Mineta Transportation Institute College of Business San José State University San José, CA 95192-0219		**10. Work Unit No.** **11. Contract or Grant No.** ZSB12017-SJAUX	
12. Sponsoring Agency Name and Address State of California SB1 2017/2018 Trustees of the California State University Sponsored Programs Administration 401 Golden Shore, 5th Long Beach, CA 90802		**13. Type of Report and Period Covered** **14. Sponsoring Agency Code**	
15. Supplemental Notes			

16. Abstract

Telecommuting, the practice of working remotely at home, increased significantly (25% to 35%) early in the COVID-19 pandemic. This shift represented a major societal change that reshaped the family, work, and social lives of many Californians. These changes also raise important questions about what factors influenced telecommuting before, during, and after COVID-19, and to what extent changes in telecommuting have influenced transportation patterns across commute modes, employment, land use, and environment. The research team conducted state-level telecommuting surveys using a crowd-sourced platform (i.e., Amazon Mechanical Turk) to obtain valid samples across California (n=1,985) and conducted state-level interviews among stakeholders (n=28) across ten major industries in California. The study leveraged secondary datasets and developed regression and time-series models. Our surveys found that, compared to pre-pandemic levels, more people had a dedicated workspace at home and had received adequate training and support for telecommuting, became more flexible to choose their own schedules, and had improved their working performance—but felt isolated and found it difficult to separate home and work life. Our interviews suggested that telecommuting policies were not commonly designed and implemented until COVID-19. Additionally, regression analyses showed that telecommuting practices have been influenced by COVID-19 related policies, public risk perception, home prices, broadband rates, and government employment. This study reveals advantages and disadvantages of telecommuting and unveils the complex relationships among the COVID-19 outbreak, transportation systems, employment, land use, and emissions as well as public risk perception and economic factors. The study informs statewide and regional policies to adapt to the new patterns of telecommuting.

17. Key Words Telecommuting COVID-19 Travel behavior Land use Employment	**18. Distribution Statement** No restrictions. This document is available to the public through The National Technical Information Service, Springfield, VA 22161.		
19. Security Classif. (of this report) Unclassified	**20. Security Classif. (of this page)** Unclassified	**21. No. of Pages** 136	**22. Price**

Form DOT F 1700.7 (8-72)

DOI: 10.31979/mti.2022.2147

Mineta Transportation Institute
College of Business
San José State University
San José, CA 95192-0219

Tel: (408) 924-7560
Fax: (408) 924-7565

Email: mineta-institute@sjsu.edu

transweb.sjsu.edu/research/2147

ACKNOWLEDGMENTS

The California State University Transportation Consortium at San Jose State University provided funding for this study. The authors thank the great effort of the student research assistants and volunteered researchers: Erika Alvarez, Carlos Mora, Jason Kryske, Kimberly Campos, Benjamin Pochop, and Lizzet Gonzalez. The authors appreciate feedback and support from Gillian Fischer, Chandra Khan, Brigette Brown, Judith Aguirre, Valencia Teems, Cherisse Ross, Darcy Estrada. Special thanks to Mitch Weiss, Brigitte Driller, and Paul Golaszewski from the California Transportation Commission, Jan Vogel and Chris Cagle from the South Bay Workforce Investment Board, and Avital Shavit from the Los Angeles County Metropolitan Transportation Authority. However, any opinions, findings, conclusions, or recommendations in this document are those of the authors and do not necessarily reflect the views of their respective organizations.

CONTENTS

Acknowledgments vi

List of Figures ix

List of Tables xii

Executive Summary 1

1. Introduction 6

2. Literature Review 7

2.1 Pre-COVID-19 Pandemic 8

2.2 COVID-19 Pandemic 14

2.3 Post-COVID-19 Pandemic 20

3. Methodology 22

3.1 State-level Survey Design 22

3.2 State-level Interview Design 23

3.3 Regression Models 25

4. Findings from State-level Surveys 37

4.1 Descriptive Summary 37

4.2 Stratified Summary 45

5. Findings from State-level Interviews 66

5.1 Historical and Current Patterns of Telecommuting 66

5.2 Future Trend of Telecommuting 66

5.3 Retail and Wholesale 68

5.4 Education Services 68

5.5 Health Care and Social Assistance 69
5.6 Professional and Business Services (Software, Construction Materials Delivery) 71
5.7 Federal, State, and Local Government 72
5.8 Finance and Insurance 74
5.9 Entertainment and Recreation 75
5.10 Manufacturing 77
6. Findings from Regression Analyses 80
6.1 Secondary Data Summary 80
6.2 County-Level Regression Analyses 82
6.3 Panel Data Analyses 83
7. Summary & Conclusions 94
7.1 Overall Telecommuting Patterns from the State-level Surveys 96
7.2 Overall Telecommuting Patterns from the State-level Interviews 99
7.3 Overall Telecommuting Patterns from the Regression Analyses 100
7.4 Limitations and Future Work 101
Appendix A State-level Surveys 103
Appendix B State-level Interviews 114
Bibliography 116
About the Authors 122

List of Figures

Figure 1. Telecommuting and COVID-19 across the California Framework of Analysis 7

Figure 2. County of Los Angeles COVID-19 Cases, Policy, and Travel Behavior, March 2020-August 2021 16

Figure 3. General Explanatory Model of the Relationship between the COVID-19 Pandemic and Commuting Behavior 30

Figure 4. Survey Responses: Commuting to Work by Different Modes 40

Figure 5. Survey Responses: Commuting Distance and Time (One-Way) 41

Figure 6. Survey Responses: Infrastructure and Travel 41

Figure 7. Number of Survey Respondents Working and Living in Each County 42

Figure 8. Survey Respondents' Work Industries and Organization/Company Size 42

Figure 9. Survey Responses: Telecommuting Experience 43

Figure 10. Survey Responses: Workplace Operations Changed During COVID-19 44

Figure 11. Survey Responses: Telecommuting Preference and Expectation Over the Next Three Years 44

Figure 12. Survey Responses by Gender: Commuting Preferences for the Future 46

Figure 13. Survey Responses by Gender: Work Industries of Respondents 46

Figure 14. Survey Responses by Age: Commuting to Work by Driving Alone 48

Figure 15. Survey Responses by Age: Equipment and Internet Access 49

Figure 16. Survey Responses by Age: Feeling Isolated When Telecommuting 49

Figure 17. Survey Responses by Race: Ideal Days of Commuting for the Future 50

Figure 18. Survey Responses by Race: Respondents Working in a Management Position 51

Figure 19. Survey Responses by Race: Equipment and Internet Access 51

Figure 20. Survey Responses by Race: Feeling Isolated When Telecommuting 52

Figure 21. Survey Responses by Race: Separating Home and Work when Telecommuting 52

Figure 22. Survey Responses by Education: Ideal Days of Commuting in Future 54

Figure 23. Survey Responses by Education: Equipment and Internet Access 54

Figure 24. Survey Responses by Income: Ideal Days of Commuting Over the Next Three Years 56

Figure 25. Survey Responses by Income: Equipment and Internet Access 56

Figure 26. Survey Responses by Work Status: Ideal Days of Commuting Over the Next Three Years 57

Figure 27. Survey Responses by Work Status: Equipment and Internet Access 58

Figure 28. Survey Responses by Marital Status: Ideal Days of Commuting Over the Next Three Years 59

Figure 29. Survey Responses by Marital Status: Equipment and Internet Access 59

Figure 30. Survey Responses by Number of Children: Ideal Days of Commuting Over the Next Three Years 61

Figure 31. Survey Responses by Number of Children: Flexibility During COVID-19 61

Figure 32. Survey Responses by Number of Children: Improved Working Performance when Telecommuting 62

Figure 33. Survey Responses by Number of Children: Feeling Isolated when Telecommuting 62

Figure 34. Survey Responses by Number of Children: Separating Home and Work when Telecommuting 63

Figure 35. Survey Responses by Number of Cars: Ideal Days of Commuting Over the Next Three Years 64

Figure 36. Survey Responses by Overall Health: Ideal Days of Commuting Over the Next Three Years 65

Figure 37. Survey Responses by Overall Health: Equipment and Internet Access 65

Figure 38. COVID-19 Cases and Travel Behavior in Los Angeles County..... 89

Figure 39. COVID-19 Cases and Travel Behavior in California..... 90

LIST OF TABLES

Table 1. Variables Used in the Demand-Side Telecommuting Studies 11

Table *2*. Summary of COVID-19 Impacts on Telecommuting and Future Trends 17

Table 3. Profile of Experts Interviewed 25

Table 4. Data Sources for Regression Analysis Independent Variables 31

Table 5. Sociodemographic Information of Survey Respondents 38

Table 6. Regression on Workplace Trips for California Counties 86

Table 7. Regression on Residence Trips for California Counties 88

Table 8. Panel Data Analysis of Monthly County-Level Travel Behavior, February 2020 – January 2022 91

Table 9. Panel Data Analysis of Monthly County-Level Travel Behavior, February 2020– February 2021 92

Table 10. Panel Data Analysis of Monthly County-Level Travel Behavior, March 2021 – January 2022 93

Table 11. Summary Results for Each Method and Across Each "TELE" Element 95

Executive Summary

The COVID-19 pandemic caused people's travel behaviors to change significantly. During the initial period of the pandemic, there was a substantial increase in people working from home, as well as a significant reduction in private vehicle commuting, public transit use, and other transportation options. Since that initial period, these travel behaviors gradually moved in the direction of pre-pandemic levels, and a new normal appears to have been reached in late 2021. Findings show that telecommuting practices in California have clearly been accelerated by COVID-19 and have been influenced at the county level by pandemic-related policies, public risk perceptions, home prices, broadband rates, and government employment rates at various stages of the pandemic. This study aims: 1) to explore the associations between various factors and telecommuting patterns before and during the pandemic in California; 2) to estimate the impacts of telecommuting on transportation systems, employment and workforce characteristics, land use, and emissions; and 3) to summarize trade-offs, barriers, and best practices of telecommuting.

This study examines state-wide trends and preferences in telecommuting before and during the COVID-19 pandemic and explores the relationships between telecommuting and the transportation system, employment and workforce characteristics, land use, and emissions. This study evaluates patterns in telecommuting behaviors and preferences, and identifies relevant factors using three primary methods: first, surveys of a sample of employees residing in the state of California identified using a crowd-sourced online platform; second, targeted interviews of managers and executives in ten key economic sectors, and third, statistical regression analysis of county-level secondary data from national, state-level, and regional sources. This study provides a framework to analyze historical, current, and future data from both employers' and employees' perspectives to explore the impacts of the COVID-19 pandemic on telecommuting patterns and trends across California. In addition, the results promise to be of use to policy makers in California and beyond to initiate legislative measures to resolve issues in transportation, workplace policy, land use, and environmental planning.

The survey conducted for this study shows that, compared to pre-pandemic levels, people were more likely to have a dedicated workspace at home, gained flexibility to choose their own schedules, and improved their working performance. While employees had received adequate training and support for telecommuting during the pandemic, they often felt isolated and found it difficult to separate home and work life. Yet when asked about their preference for the next three years, only 14% of survey respondents preferred fully working in the office. Such telecommuting patterns and preferences varied across socioeconomic and demographic variables. In terms of workplace practices, telecommuting policies were not commonly designed and implemented until COVID-19. While the benefits of telecommuting (e.g., productivity) were apparent to respondents, challenges also existed (e.g., training, collaboration, recruitment). Industries also emphasized various components (e.g., office space, time management) necessary for successful telecommuting in the future.

Below, we summarize major findings of the three sections.

The survey analyses were conducted on 1,985 original responses from Californians. Results show that as a consequence of the COVID-19 pandemic on average:

- Driving to work alone dropped from five days a week to zero days.
- Commuting by private vehicle, public transit, and other modes decreased significantly.
- Commute distance declined from 6–20 miles to 0–20 miles.
- Commute time dropped from 10–40 minutes to no commute at all.
- Of all respondents, 55% of respondents saw traffic congestion improve. Further, 31% of respondents reported that their workplace moved to partial work from home, 20% to permanent work from home, and 29% had no change.

During COVID our survey found that:

- About 40% of respondents were furloughed from their job.
- About 55% of respondents had more flexibility to choose their own schedules.
- About 56% of respondents claimed that their working performance had improved since working from home and that they had received adequate training and support for telecommuting.
- About 54% of respondents felt isolated and found it difficult to separate home and work life when working from home.
- About 25% of respondents found it ideal to fully work from home, and 25% of respondents found it ideal to work for 3 days in the office. Only 14% of respondents wanted to work fully in the office.

Looking to the future, our survey found that

- About 43% of respondents expected no change to their employer's office space over the next three years; 24% of respondents expected the office space to be reduced by more than 26%.
- Opinions were divided on whether increased teleworking availability affected decisions to move homes. If workers live further from their workplaces, this has important implications for the future of land use and transportation policy.

The interview analyses, which also focused on California and included feedback from 28 interviewees, show that:

Before the pandemic

- Several companies did not have an official telecommuting policy.
- Some companies have already started flexible and remote work before the pandemic.

During the pandemic

- Office staff shifted to full/hybrid telecommuting, while essential or filed operations remained in person.
- Many companies are currently developing an official telecommuting policy.
- Most companies converted to full/hybrid telecommuting mode during COVID-19.
- Several interviewees experienced higher productivity levels when telecommuting, except during the transition period.
- Several interviewees, especially in high-cost areas, indicated a strong preference to stay in the telecommuting mode due to lower commuting costs and better quality of life.
- Some respondents' colleagues moved to other states and do not plan to move back to California.
- Several interviewees indicated that telecommuting enhances the quantity and quality of the talent pool and reduces the costs of hiring and employment.
- Some organizations stated concerns about employees living outside California because of tax and regulatory matters.
- Several interviewees saw remote training and mentoring as the primary challenges.
- Some employers have stopped expanding, reducing, or rearranging the office space during COVID-19. Other have consolidated office locations and adopted hoteling/hotdesking.
- Several companies ask employees to provide vaccination records. A few companies provided incentives to encourage employees to get vaccinated.
- To design workforce development programs that train managers and workers for success when using flexible work practices, some interviewees emphasized maintaining strong company culture by enhancing interpersonal relationships and trust as well as building

connections among people virtually. It is essential to develop time management and prioritization skills that maximize employees' effectiveness in response to distractions at home.

After the pandemic

- The pandemic accelerated the trend toward more flexible working practices.
- Companies with reduced, consolidated, or rearranged workspaces planned to continue with those measures.
- Some companies have lost employees to other companies which offered a similar salary with a full work-from-home option, and they plan to match this to retain and even attract more talent.

The regression and time-series analyses show that:

- Early in the pandemic, transit trips and trips to workplaces, grocery and retail stores, and pharmacies all decreased substantially. In contrast, "residence trips" (i.e., staying at home rather than traveling) increased, and while these patterns have shown a trend toward pre-COVID-19 rates, travel behaviors appear to have shifted for good.
- The relationships between the COVID-19 outbreak, government policy, public risk perception, economic factors, and travel behaviors are complex, interactive, and dynamic. For example:
    - Early shifts in travel behavior appear to have been influenced by policy, with the California Stay Home Order triggering reductions in workplace trips and increases in "residence trips." Even though COVID-19 cases, hospitalizations, and deaths were relatively low in the early period, high levels of risk perception, high unemployment rates, and increased federal government transferred all influenced behaviors in that early period.
    - Moreover, as California policy shifted in response to COVID-19 surges and declines, travel behavior responses appear to have been influenced by both government policy and public risk perception simultaneously.
    - That said, following the end of the California tiered system, a "new normal" appears to have emerged. Despite surges associated with the delta and omicron variants in fall and winter 2021, respectively, travel behavior remained stable during this period, without major changes. This suggests that public risk perception is no longer a mediating factor of travel behavior, possibly influenced by the roll-out of COVID-19 vaccinations from December 2020 onwards.

- At the California county level, very few hypothesized location-specific variables appear to have influenced changes in travel behaviors at key moments during the pandemic. However, some exceptions include:
    - For workplace trips in the summer of 2020 (in the week after a second series of restrictions was imposed), counties with higher poverty rates saw outsized reductions in workplace trips. In contrast, counties with large average household sizes experienced higher-than-average workplace trips.
    - For workplace trips in the winter of 2020–21 (during the height of California's third wave), rural counties experienced higher-than-average workplace trips.
    - For "residence trips" across all time periods analyzed, counties with higher poverty rates saw more people staying home during the pandemic. This could reflect increased telecommuting rates, or disproportionate levels of unemployment, among poorer communities.
    - Also, counties that are more rural experienced lower-than-average "residence trips," but this was only statistically significant during the height of California's third wave.
- For trips to grocery stores and pharmacies, the only significant and impactful positive relationship was observed for counties with higher poverty rates.

The COVID-19 pandemic has motivated stakeholders in California to rethink and revisit telecommuting policies. Examples include policy recommendations on commercial real estate, downtown office buildings, and the businesses that rely on them. This study reveals advantages and disadvantages of telecommuting from both surveys and interviews and unveils the complex relationships between the COVID-19 outbreak, government policy, public risk perception, economic factors, and travel behaviors. This study calls for policy makers to plan for telecommuting policies to adapt to the new patterns (e.g., allowing more flexibility in zoning, parking, parklets, and focusing on initiatives that bring people back home safely).

1. Introduction

Telecommuting, which enables employees to perform job tasks remotely at home, has grown steadily in its prevalence over the last few decades. Prior to the COVID-19 pandemic, California's telecommuting rates were about 20% (Prager et al., 2019). The COVID-19 pandemic has witnessed an increase of about 35% of telecommuting and 45%–55% in jobs being telecommuting-compatible (Dey et al., 2020). In general, the compounding impacts of pandemic lockdowns and a deep economic recession have led to a significant decline in road traffic and changing transportation patterns. These changes raise important questions about the factors influencing telecommuting levels before and during, as well as preferences after the outbreak of COVID-19, and about the extent to which changes in telecommuting have influenced transportation patterns, employment, land use patterns, and emissions.

While some telecommuting literature explores the demand-side factors influencing adoption and frequency rates, studies have not examined these factors across a large economy (such as California). Additionally, studies have not focused on spatial, demographic, and equity-based factors to inform large-scale policy making. Studies have highlighted various important drivers (e.g., the cost of commuting, expected isolation and lack of communication). However, these factors have not been explored within the context of the major societal and transportation-system changes we have seen during the COVID-19 pandemic.

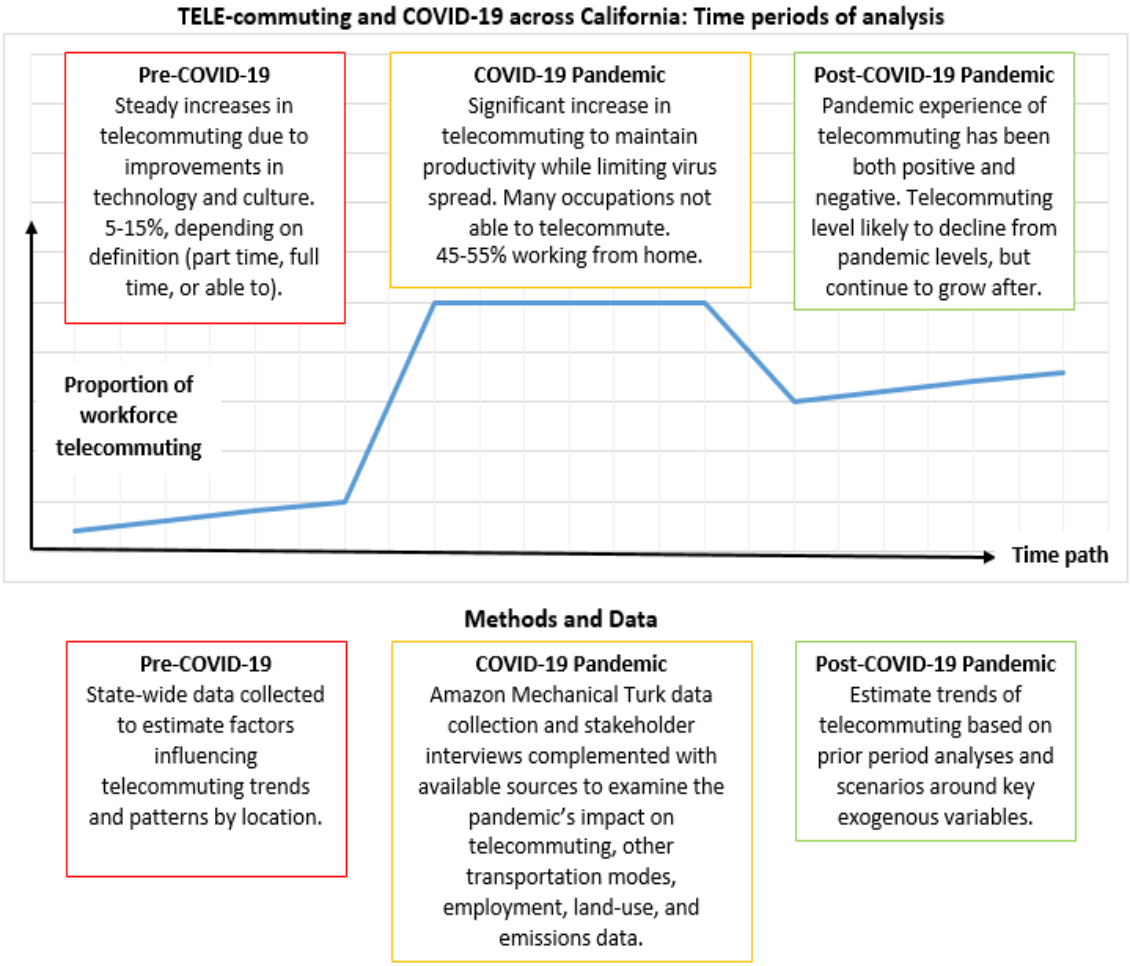
State agencies, metropolitan planning organizations, and local governments are increasingly confronted with questions about what factors are associated with telecommuting and whether the trends of telecommuting might shift in the "new normal." Therefore, this project analyzes archival datasets, conducts a combination of state-level telecommuting surveys and interviews for employees and employers using innovative tools, and develops regression models to explore the patterns and trends of telecommuting in California. This study contributes to the literature by developing a framework to analyze historical, current, and future data from both employers and employees to identify the impacts of the COVID-19 pandemic on telecommuting patterns and trends. The study will be helpful for policy makers as well as companies and organizations in California and beyond, supporting them in implementing measures to resolve issues in transportation, workplace, land use, and environmental sectors. Importantly, the project will pave the way for the development of sustainable, equitable, and resilient cities.

We organize the remainder of the report as follows. Chapter II presents the literature review. Chapter III introduces the research methodology. In Chapters IV, V, and VI, we report the findings for the state-level surveys and interviews and the regression models. Chapter VII concludes the study with a summary of the findings, implications, and limitations.

2. Literature Review

This literature review is designed to support the analysis conducted in this report. There is a broad and growing literature on telecommuting, which includes contributions from transportation studies, human resource management, and disaster and emergency management, among other fields. We primarily use the term "telecommuting" in this report, but there are subtle yet important differences between the terms "telework," "work from home," and "flexible workplace practices" (FWP), among others. As reflected in Figure 1, we divide the literature review into three periods: (1) before the COVID-19 pandemic; (2) during the COVID-19 pandemic; and (3) after the COVID-19 pandemic. Overall, the COVID-19 pandemic period is particularly interesting as a focus of study because of the substantial and unprecedented increase in telecommuting.

Figure 1. Telecommuting and COVID-19 across the California Framework of Analysis



2.1 Before the COVID-19 Pandemic

The analytical framework used in the respective section of the report (Section VI) uses state-wide data to estimate factors influencing aggregate telecommuting trends across locations. As such, this section of the literature review first explores telecommuting trends and barriers prior to the COVID-19 pandemic and then investigates the demand-side factors influencing the use of telecommuting across regions. However, given the relatively small number of studies in that focused area, this literature also examines the demand-side literature at the organizational level.

2.1.1 Telecommuting Trends and Barriers to Expansion

In the years immediately preceding the COVID-19 outbreak, full-time California telecommuting rates were around 5% and part-time rates were around 15%, with a higher percentages of employees eligible to work-from-home (Prager et al., 2019). While these figures had been increasing in prior years, especially for part-time employees and those eligible to work from home, telecommuting had not reached the levels that scholars in the early decades of the field had anticipated (Prager et al., 2019).

California was at the forefront of the telecommuting field from its inception. Notable scholars, practitioners, and programs in the field during the 1980s and 1990s were based in the state, traffic and congestion in major cities was notorious, and significant advances in IT technology and internet systems originated there.

Over the decades, as telecommuting was adopted around the world, a growing literature documented its benefits with respect to worker productivity, work-life balance, recruitment, workplace morale, regional congestion and emissions, and disaster management (Eom et al., 2016). When workers have control over their schedule and can save time by eliminating the commute, studies show they are more satisfied and productive (Rhoads, 2015). In the past, technological limitations posed a problem for remote work, but today, modern-day technologies and platforms, including cloud technology, make remote work more feasible than ever before.

Despite all this, formal telecommuting programs and telecommuting uptake were not commonplace, even though most workers surveyed expressed a desire to telework (Global Workplace Analytics, 2013). Numerous factors could explain this limited expansion, including: (1) commute times not being sufficiently costly or increasing quickly enough to stimulate a response; (2) benefits identified in prior research being overstated or not generalizable outside of the study area; (3) the organizational costs of telecommuting program implementation being too expensive and uncertain; (4) organizations being hesitant to relinquish negotiation and motivation tools; and (5) public policy incentives being insufficient to stimulate significant change (Prager et al., 2022).

2.1.2 Demand-Side Factors Influencing Telecommuting

There is a small and growing academic literature exploring the broader societal factors influencing telecommuting use across locations and organizations. Table 1 is an expanded version of a table found in the Ph.D. dissertation of Mohja Rhoads (Rhoads, 2015). These studies have used varying sample sizes to examine causal relationships within specific locations (see the table for details). This section focuses on studies in which independent variables are found to be related with statistical significance to telecommuting. Methods are discussed for each paper in Table 1, and further in Section 3 below with respect to the methods used in this study.

Mannering and Mokhtarian used multinomial logit regression analysis of survey responses among employees across California and found different significant variables by location (Mannering & Mokhtarian, 1995). For example, the San Diego survey identified positive associations between adoption and frequency of telecommuting with vehicles per household, and negative associations with clerical occupations and family orientation. For the adoption of telecommuting only, significant positive associations were identified for being a woman with children under 5 years, while for frequency of telecommuting only, significant positive associations were identified for the number of people in the household, possession of a home office, and being full-time. In comparison, the San Francisco survey found only family orientation (i.e. the composition of households such as the number of parents and children) to have a significant effect, and only on frequency of telework; however, it found significant positive effects of income per capita in household and the presence of children under the age of 5 on the adoption and frequency of telecommuting.

Drucker and Khattak conducted a national survey and found a positive association between working from home and higher educational levels and the presence of children in the household (Drucker & Khattak, 2000). Using unordered and ordered models—both logit and probit regression analysis—they also found that men and drivers are more likely to work from home than women or nondrivers. Additionally, they found that lack of free parking at work promotes working from home. Popuri and Bhat conducted a survey in New York and found that women are less likely to telecommute than men if there are no children in the household (Popuri & Bhat, 2003). However, if children are present in the household, women and men are similarly likely to telecommute, though women are likely to telecommute more frequently. Among telecommuters, older individuals are found to be telecommuting more frequently than younger individuals. Additionally, individuals who drive to work, individuals with a driver's license, individuals who drive to work, and individuals with several vehicles in their household are more likely to work from home.

Sener and Bhat used a binary choice-ordered response model to analyze data from the Chicago Regional Household Travel Inventory and found that women are less likely to telecommute than men. Full-time individuals are more likely to telecommute than those working part-time (Sener & Bhat, 2011). However, among telecommuters, full-time individuals telecommute less frequently

than part-time individuals. Individuals with flexible work schedules are more likely to telecommute and to do so frequently. Additionally, Sener and Bhat found that employees in the communications industry are more likely to telecommute and to do so frequently, and likewise for those in service-related industries. Individuals in households with higher incomes and more workers tend to telecommute more often. In a related vein, individuals who have pro-bike and pro-transit views have a higher propensity to telecommute relative to others. Additionally, those who make several non-work trips on work days are more likely to telecommute, as are those who do not have to pay to park at their workplace.

Consistent with previous research, Walls et al. used probit and ordered probit models and found that higher education levels have a positive association with the likelihood of telecommuting (Walls et al., 2007). Similarly, older individuals are also more likely to telecommute. However, the likelihood of telecommuting depends largely on an individual's job characteristics, and the quantitative effects of job characteristics are at least as important as demographics. Walls and colleagues' observations led them to conclude that where individuals work and the type of job they hold affect the likelihood that they telecommute. For example, they found that individuals in sales jobs, education and training, and architecture and engineering are more likely to telecommute. In contrast, jobs in health care and construction are less conducive to telecommuting. Additionally, individuals who work in mid-size firms (25–250 employees) are less likely to telecommute than individuals who work at very small (< 25 employees) or very large (> 250 employees) firms. The length of commuting to and from work significantly affects the employee's frequency of telecommuting.

Table 1. Variables Used in the Demand-Side Telecommuting Studies

Study	Sample Size and Location	Dependent Variable and Method	Independent Variables
Mannering & Mokhtarian, 1995	65; 65; 433 San Francisco; Sacramento; San Diego	Frequency of Telecommuting Ordered Response; Multinomial Logit Regression Analysis	Number of People in HH; Female w/small children; Home office space; Vehicles per capita; Automobile as a status symbol; Hours worked; Supervises others; Clerical occupation; Full-time; Level of control over work; Productivity in the workplace; Familiarity with Telecommuting; Lack of self-discipline; Family orientation; Satisfaction with Life
Drucker& Khattak, 2000	23,712 Nation	Frequency of Work at Home Ordered and Unordered Models Probit and Logit Regression Analysis	Age; Gender; Single; Age of children in HH; Education; HH Income; Driver; Number of Vehicles; Time to Work; Rural; Pays to Park; Availability of Bus, Train, Streetcar and Rail
Pouri & Bhat, 2003	6,523 and 1,018 New York	Choice and Frequency of Telecommuting Binary and Ordered Response	Gender; Female w/children; Age; Marital Status; Education; Drives to Work; Vehicles; Licensed Driver; Takes Transit to Work; Works for a private company; F2F contact is needed at work; Part-time status; Pays to park at work; Length of employment; Income; Multiple phone lines
Walls, Safirova, & Jiang, 2007	2,315 Southern California	Likelihood and Frequency of Telecommuting Probit and Ordered Probit	Age less than 30; No College; White; Kids between the ages of 0 and 5 and 6 and 17; Gender; Part-time or Full-time; 11 categories for organizations industry; 11 categories for worker's occupation; Size of firm; Commute
Sener & Bhat, 2011	9,264 and 1,534 Chicago	Choice and Frequency of Telecommuting Binary and Ordered Response	Gender; Female w/children; Younger than 30 years; Education; Driver's license; Full-time; Workplace flexibility; Sector: Communications Service portions of Finance, Real Estate, Professional, Scientific, or Technical, Management, Arts, Education and Health Care, Government; Income between 75 and 100K; Income > 100K; # of vehicles, #of workers in HH; Commute > 25 miles; Walk, bike or take transit to work

Study	Sample Size and Location	Dependent Variable and Method	Independent Variables
Caulfield, 2014	Republic of Ireland Census data, narrowed to Dublin	Working from home Multinomial Logit Regression Analysis	Deprivation score; Bus stops per 1,000 people; Rail availability; Broadband internet coverage; Age; Household structure; Residential density; Cars per household; Industrial group; Educational level
Sarbu, 2015	10,884 German employees	Work at home (share of employees); Intensive work at home (share of employees); Telecommuting by contract (share of employees); Work at home entirely by contract (share of employees) Probit Discrete Choice Model	Male (share of employees); Female (share of employees); Children <6 years (share of employees); No degree (share of employees); Only secondary school (share of employees); Secondary school and vocational education (share of employees); Only Abitur (share of employees); Abitur and vocational education (share of employees; Abitur and studies (share of employees; Age (years); Share of employees <30 years; Share of employees 30–50 years; Share of employees >50 years; Work with computers (share of employees; Tenure (years); Overtime (hours per month); Work time (hours per week; Commute time (minutes); Firm with 1–19 employees (share of employees); Firm with 20–99 employees; Firm with >100 employees
Eom et al., 2016	17,214 Korean public-sector employees	Intention to use and usage behavior at "Smart Work Centers" Structural Equation Models	Gender; Age; Marital Status; Income; Job tenure; Organization type; Position; Government employment; Job category; Relocation of organization; Cost of commuting; Cost of business trips; Expected work productivity; Institutional and technological support; Burden of supporting family; Job unsuitability; Expected isolation and lack of communication; Unfriendly leadership.
Loo & Wang, 2018	608 Full-time employees conducting e-activities in Nanjing, China	E-working and E-shopping Binary and Ordered Logit Regression Models	Gender; Age; Educational level; Children under 16; Usually drive to workplace; Usually drive to shopping center; Smartphone use in 2012; Daily internet use time; Distance to workplace; Distance to nearest metro station; Distance to nearest shopping center

Source: Authors' adaptation from Rhoads (2015)

Caulfield's multinomial logit regression analysis of 2011 census data for the Greater Dublin region of Ireland found that broadband internet coverage, public transport availability, and occupation type all significantly influence the likelihood of working from home (Caulfield, 2015). Living in areas with higher incomes, fewer bus stops, no rail, older populations, more single-person households, lower residential density, and more broadband internet coverage all increased the likelihood of working from home. Sarbu used individual-level data on 10,884 German employees and found that men have a higher likelihood of working from home, yet women are likely to work from home for more hours on average (Sarbu, 2015). The study also found that employees with children less than 6 years old, who worked overtime, and who worked longer hours were all more likely to work from home and were likely to work longer hours from home.

The most sophisticated conceptual framework within this literature is provided by Eom et al., who explored "smart work centers"—satellite offices closer to residential locations—used by 17,214 Korean public-sector employees (Eom et al., 2016). Eom and colleagues suggest a model of influential factors consisting of "drivers" (cost of commuting, cost of business trips, expected work productivity and efficiency, institutional and technological support, and burden of supporting a family) and "constraints" (job unsuitability, expected isolation and lack of communication, and unfriendly leadership and management), which, along with factors such as organization type, relocation, gender, and position, all influence both the intention to use smart work centers, and then usage behavior. Factors used in this conceptual framework are also outlined in Table 4 below, and used to inform our regression analyses in Section VI.

Eom and colleagues used structural equation modeling and found that, unlike in Sarbu's study in Germany, here, younger employees and those with lower-status positions and shorter tenures were found to be more likely to use smart work approaches. Employees of quasi-government organizations were more likely to engage in smart work than those in traditional public sector offices. Overall, those with perceptions of higher costs for commuting and travel, higher levels of work efficiency, and more organizational and technological support were more likely to adopt smart work. On the other hand, fears of social isolation and poor communication, and the potential for problems with leadership and management, discouraged some employees surveyed.

Loo and Wang used binary and ordered logit regression models to analyze survey responses from 608 full-time workers in Nanjing, China, and found that having young children increases the likelihood of working from home (Loo & Wang, 2018). Women are also more likely to work from home, though the literature on this issue has produced mixed results. Higher education levels and longer working hours indicated more telecommuting.

In conclusion, while some telecommuting literature explores the demand-side factors influencing adoption and frequency rates (Caulfield, 2015), studies have not examined these factors across a large economy (such as California). Additionally, studies have not been operationalized with respect to spatial, demographic, and equity-based factors to inform large-scale policy making. Studies highlighted the importance of drivers including "the cost of commuting," "the cost of

business trips," "expected work productivity," "institutional and technological support," and "the burden of supporting a family" as well as constraints such as "job unsuitability," "expected isolation and lack of communication," and "unfriendly leadership and management." However, these factors have not been explored within the context of the major societal and transportation-system changes we have seen during the COVID-19 pandemic.

2.2 COVID-19 Pandemic

The analytical framework for this section of the report uses survey and state-wide data to estimate the influence of telecommuting adoption on other transportation-relevant factors such as mode choice, employment, land use, and emissions. As such, this section of the literature review first explores the use of telecommuting during the COVID-19 pandemic as well as other disruptive events. Second, this section explores literature on the impacts of shifts in telecommuting usage on other transportation-relevant factors.

2.2.1 The Use of Telecommuting During the Pandemic and Other Disruptive Events

The COVID-19 pandemic is not the first major disruptive event to impact transportation planning in general and telecommuting in particular. While studies have been conducted on the transportation impacts of major events such as the Olympics and major natural disasters (Budnitz et al., 2018; Walls et al., 2007), most explored the implications for the transportation system as a whole and focus only briefly on telecommuting. This is likely because these other events were relatively short in length and did not have the same requirements for social distancing in workplaces.

Evidence suggests telecommuting increased between 22%–25% (Dey et al., 2020) and 35% (Brynjolfsson et al., 2020) during the first COVID-19 lockdown in March 2020 and that 37%–56% of US jobs (including part-time) were telecommuting-compatible (Dingel & Neiman, 2020). Compounding impacts of pandemic lockdowns and a deep economic recession have led to traffic and commuting declining significantly in California (Apple, 2020; Google, 2020). These changes raise important questions about the factors influencing telecommuting levels before and during, as well as preferences after the pandemic, and to what extent changes in telecommuting have influenced transportation patterns, employment, land use patterns, and emissions.

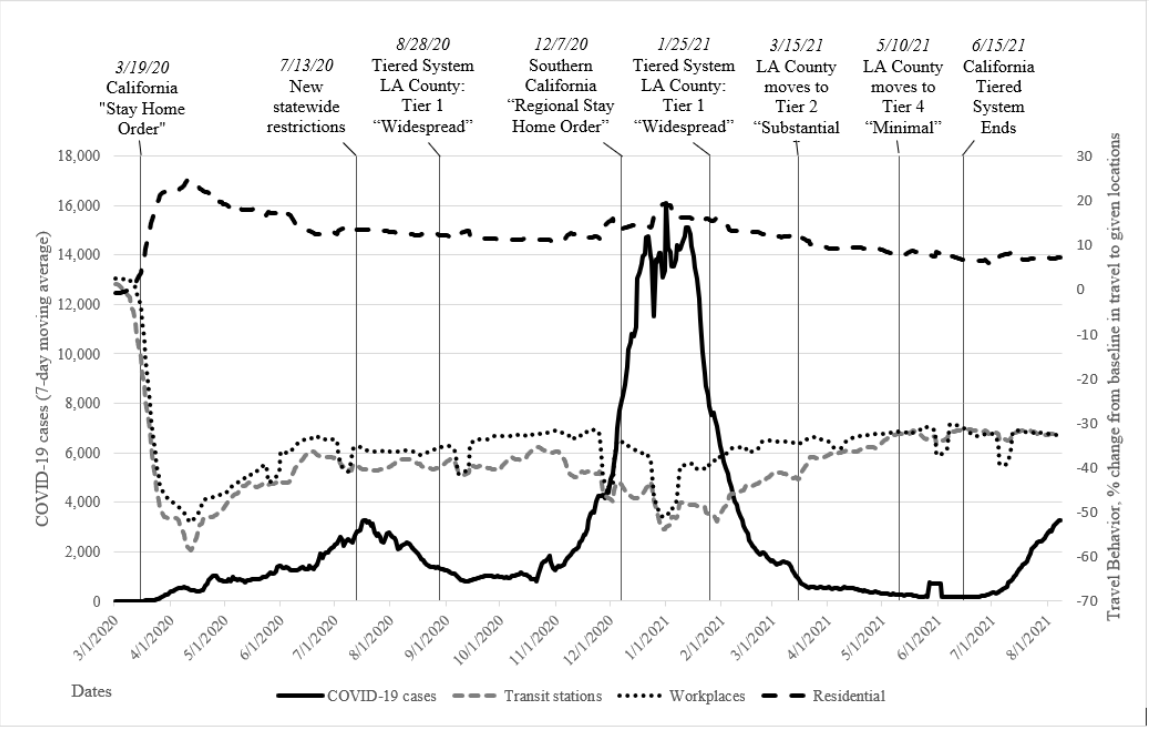
The use of telecommuting during the COVID-19 pandemic has been a major focus of scholars across numerous fields since the pandemic began. Many studies have explored the relationship between telecommuting and virus spread mitigation, the impact of telecommuting on workers, and the inequalities of access around telecommuting (de Haas et al., 2020).

While the public health benefits of telecommuting during a pandemic are clear and can mitigate the economic losses of shuttering businesses, a general theme for this literature is to serve as a counterpoint to a common narrative that telecommuting allows for an easy switch away from office work, saving workers and companies time and money while maintaining productivity. Instead,

some recent work highlights the reality of working from home. Teleworking is not a positive experience for all workers. While working from home can improve work-life balance of employees, some studies have highlighted concerns about feelings of isolation and challenges in separating home and work life (Beck and Hensher 2020; Bloom, 2020). These experiences appear to have been heightened during the COVID-19 pandemic, as workers were rushed into new modes of working without adequate training, support, or IT systems in place (Beck & Hensher, 2020). Moreover, living and working at home during lockdowns—and with limited space due to family, cohabitants, and children, who may also be working and learning from home—created telecommuting conditions that were uncommonly stressful compared with pre-pandemic experiences (Bloom, 2020). Before the pandemic, women were more likely than men to take on additional housework and childcare beyond paid work obligations. These experiences were often heightened during the pandemic (Bloom, 2020).

Another important counter-narrative is a challenge to the idea that telecommuting is available to all. Instead, many occupations and organizations are not compatible with telecommuting (Dey et al., 2020). Many lower-paid workers in service industries and customer-facing occupations were laid off during the pandemic. In addition to class-based inequalities, women and minorities bore the brunt of the unemployment impacts (DeSilver, 2020). A major factor in such inequitable outcomes is the higher likelihood of some workers—those with higher income, higher education levels, more likely white and male—to be able to telecommute.

Figure 2. County of Los Angeles COVID-19 Cases, Policy, and Travel Behavior, March 2020 – August 2021



Note*:* Authors' Calculations Based on LA Times and Google Mobility Data (Kannan et al., 2021; Google, 2021)

2.2.2 The Impacts of Telecommuting

This section focuses on the influence of telecommuting usage on other transportation-relevant factors such as transportation modes, employment, land use, and emissions. As discussed above, telecommuting had only seen limited adoption prior to the COVID-19 pandemic, which limited the number of studies exploring these relationships. Nonetheless, this literature has generated important findings about the impacts of telecommuting. Figure 2 maps COVID-19 cases and government policy changes in the County of Los Angeles against travel behavior data from Google Mobility for transit stations, workplaces, and residences.

Table 2. Summary of COVID-19 Impacts on Telecommuting and Future Trends

Transport Policy Issue Area	Impact of COVID-19	Impact on Telecommuting	Future Trends
Regional Transport System	Significant reduction in travel, especially public transit (Figure 2).	Telework offsets commutes for 45%–56% of jobs (Dey et al., 2020). Telecommuters more likely to have been car drivers (Prager et al. 2019).	New commuting patterns and fear of public transit will likely stick for many. Some will return to offices, but average commutes will be less frequent and further (Prager et al., 2022).
Emissions	Significant initial reduction in emissions (Berman & Ebisu, 2020; Shilling, 2020) offset by increases in private vehicle use instead of public transit (Figure 2).	Literature shows unclear emissions impact of telecommuting Increase in local errands and home heating may offset reduce commute emissions (Mokhtarian & Varma, 1998; Zhu, 2013 Zhu & Mason, 2014).	Long-term impacts may be influenced by land use and transport system factors for suburban residences of teleworkers (Budnitz et al., 2020).
Land Use	Lockdowns and social distancing requirements reduce demand for commercial real estate. City rents decline as desire for more space reduces demand for dense areas (Martinez et al., 2020).	Organizations look to downsize, end leases, or repurpose workplaces. Telecommuting enables privileged employees to move further away from workplace (Zhu, 2013).	While workplace demand in denser urban areas will return as the pandemic eases, lasting telecommuting will see suburban and satellite locations increase in importance (Ettema, 2010; NCHRP, 2019).
Employment	Unprecedented disruption to workplaces through unemployment and telework (Martinez et al., 2020).	Most telecommute-compatible jobs likely to continue with flexible workplace practices (Prager et al., 2022).	High demand for workers in post-COVID-19 environment means many companies offering FWP to hire and retain.
Social Equity	Health and unemployment disproportionately affect poor and communities of color (Martinez et al., 2020).	Telecommuters are wealthier, whiter, more senior; poor and minority employees more likely to work in person (DeSilver, 2020; Prager et al, 2019).	Benefits of telework and FWP are experienced by more workers, especially as new graduates enter workforce. However, inequalities will remain (DeSilver, 2020).

Source: adapted from Prager, Rhoads, and Martinez (2022)

Telecommuting might appear to lead to a net reduction in traffic, but only with the assumption that a regular commuter is no longer using a previously congested transport system, and hence their vehicle miles traveled (VMT) and emissions are reduced. This assumption is clearly an over-simplification for several reasons, as highlighted in various different literature sources.

First, the telecommuters' previous commuting patterns and mode choices matter. They could have been unemployed, or worked part-time and traveled at non-congested hours. Hence, the impact on system congestion would not be reduced, but their VMT and emissions still could be. While the telecommuter would have driven to work, they could have used any number of alternative transportation modes, each of which would impact congestion, VMT, and emissions to varying degrees (Zhu, 2013).

Second, once the first-order reductions are established, it is possible that telecommuters offset some or all these reductions with additional non-commute trips, such as household or personal errands. Many regular commuters create efficient journey chains to build errands into their commutes. Moreover, some telecommuters might relocate their home to take advantage of more affordable or desirable housing locations when not tied as tightly to a particular location. In this way, VMT might be increased overall when part-time commuting or occasional office trips are required (Budnitz et al., 2020).

Finally, telecommuting centers (such as co-working spaces) could play a role in complicating the picture further. Bieser et al. found that on days at the telecommuting center, respondents spent half as much time traveling as on regular commute days, on average, while on days working from home, people spent even less time traveling (Bieser et al., 2021). Dissanayake and Morikawa found that satellite/suburban centers would reduce VMT and emissions significantly (Dissanayake & Morikawa, 2008).

Numerous articles examine the impacts of COVID-19 on the transportation system more broadly. Substantial reductions in overall travel, as well as across private motor vehicles and public transport, were observed across major regions (SCAG, 2020; US BTS, 2021). In Australia, Beck and Hensher found that overall trips decreased substantially and across all modes (Beck & Hensher, 2020). However, as a proportion of overall travel, private vehicle travel remains stable, while public transport falls, and non-motor travel increases. Survey respondents found public transport modes and taxi to be the least comfortable modes (Beck & Hensher, 2020). The authors also found that when respondents' work can be completed from home, there is an 11% increase in the probability of a decrease in car use. Similar patterns are observed by de Haas and colleagues in the Netherlands (de Haas et al., 2020): substantial reductions in overall trips (55%) and distance travelled (68%) were accompanied with large increases in working from home—from 6% up to 39%.

Telecommuting is often implemented by both employers and employees to save travel time and cost (Peters et al., 2004), reduce traffic congestion (Dissanayake & Morikawa, 2008), and cut VMT and emissions (Shabanpour et al., 2018). However, as discussed above, telecommuting may

not necessarily reduce emissions, as people who telecommute might have less frequent yet longer commutes as they live further away from their workplace and increased local trips (e.g., shopping, school trips) that may have been previously "chained" into their commutes (Zhu, 2012).

While government agencies seek emissions reduction, telecommuting may not be a simple antidote. The impacts of telework are ambiguous. For example, Mokhtarian found that telework may reduce total distance driven by eliminating commute trips, though teleworkers may compensate for commute time savings with additional recreational travel (Mokhtarian, 2004). Mokhtarian and Varma found that telework reduced driving distances by 11.5%, even though the number of personal trips increased slightly on telework days (Mokhtarian & Varma, 1998). Zhu and Mason suggested telecommuters have more VMT for both daily work and non-work trips than non-telecommuters (Zhu & Mason, 2014). Using traffic data from across the U.S., the authors was found that total VMT at the county and state level had declined by 61% to 90% following the various government stay-at-home orders during the COVID-19 pandemic (Shilling, 2020). Additionally, the COVID-19 pandemic has led to a reduction of greenhouse gas emissions (Berman & Ebisu, 2020).

Telecommuting is also related to employment and workplace characteristics (Peters et al., 2004). Telecommuting shares vary among different industries (OECD, 2020), gender groups (Bélanger, 1999), and income levels (De Abreu e Silva & Melo, 2018). The recent "GO-Virtual Initiative", a collaborative research and outreach effort based in the South Bay region of Los Angeles identified major obstacles to expand telecommuting there, which includes inefficient organizational implementation and management, lack of policies in place, inadequate training, and shortage of tax credits or stipends (Prager et al., 2019). However, that study was conducted in a specific Californian region prior to the COVID-19 outbreak. It is unclear how these factors could characterize state-wide telecommuting patterns and trends during and after the pandemic.

The COVID-19 pandemic has also highlighted across a broader audience the previously-observed inequalities of telecommuting (DeSilver, 2020; Prager et al., 2019). That said, prior to the pandemic, there were only limited studies on the equity dimensions of telecommuting, especially during disasters.

Outside of a pandemic environment, home environments have the potential to provide distraction-reduced atmospheres, increasing an employee's output. On the other hand, homes might contain other distractions such as home entertainment, housework, or friends and family. That said, flexible work allows people to schedule an appointment or run errands without losing a full day of work and reduces unscheduled absences.

The relationship between telecommuting and land use is a complex and intriguing one. Telecommuting may impact land use through land density, land value, and zoning (Ettema, 2010). Telecommuting could reduce travel costs, contributing to an increase in land values and densities by improving accessibility (NCHRP, 2019).

Telecommuters may relocate their homes, reshaping both residential and workplace land uses (Mokhtarian, 2004). Handy and Mokhtarian highlight the influence that land use and zoning might have on telecommuting adoption, arguing that the relationship between telecommuting and land use is interactive (Handy & Mokhtarian, 1995). Telecommuting is a facilitator rather than a cause of land use changes; telecommuting allows a worker to move farther away, but other factors determine whether they actually choose to (Mokhtarian, 1997).

2.3 After the COVID-19 Pandemic

Projections of telework in the post-COVID-19 world can be informed by trends in the pre-COVID-19 workplace, including experiences of telework during the pandemic and lockdown (Prager et al., 2022). Prior to COVID-19, it remained unclear why telecommuting and other flexible workplace practices were not expanding more quickly given the evident benefits (Prager et al., 2019), and in contrast projections since the 1990s that anticipated greater growth (Handy and Mokhtarian, 1996). The COVID-19 lockdown created a shock to the system, and a substantial increase in telework. Following the COVID-19 outbreak, will telework return to pre-COVID-19 levels? Or will there be a lasting shifting in workplace culture?

This section explores numerous literature-informed factors that might provide insight into future of telecommuting with respect to the conditions experienced during the COVID-19 lockdown (Prager et al., 2022). First, the benefits of telecommuting identified above and in prior research (see, e.g. Rhoads, 2015 for a detailed summary) were not experienced by all organizations and workers. Research prior to COVID-19 highlighted that telecommuting could be a challenge for some employees, including feelings of isolation from work colleagues and concerns over separating home and work life (Gordon, 2015). Such concerns were likely exacerbated by the unique context of the COVID-19 lockdowns, including working in tight home spaces among family members and roommates. Such issues were particularly salient for parents with school-age children in California, as schools remained closed—with teaching provided virtually—for around one year following the initial lockdowns. Moreover, the lack of flexibility with respect to attending workplaces (a key benefit of telecommuting) could negatively influence employee morale and a lack of face-to-face meetings could cause declines in productivity and innovation, especially in the medium- to long-term (Bloom, 2020). After the COVID-19 lockdowns, many of these challenges are likely to have been removed, or more lasting solutions developed by organizations and employees alike (Prager, Rhoads & Martinez, 2022).

Prior to COVID-19, telecommuting expansion appeared to have been limited by high and uncertain organizational. Many jobs are highly dependent on physical presence and are not possible or challenging to undertake remotely. Prior to the pandemic, an estimated 50% of US workers have some parts of their job that can be performed remotely, and 20%–25% with a high frequency (Global Workplace Analytics, 2013). As discussed above, other studies used similar methods—based on combining occupational data by sector with known occupational characteristics—to

estimate telecommuting compatibility of US workers as between 45 and 55 percent (Dingel & Neiman, 2020; BLS, 2020).

Given these considerations, it had appeared before the pandemic that a cultural change among managers and executives needed to occur, for telecommuting to be more widely adopted. HR managers were found to view telecommuting as more feasible for certain occupations and smaller companies (Pérez Pérez et al., 2003), while on the other hand being eligible but blocked from telework by managers can cause disaffection among employees (Mahler, 2012). For many organizations, the COVID-19 lockdowns forced a sudden cultural change. The costs of transition were borne by organizations as they developed, implemented or expanded telecommunications systems, remote working processes and policies, and experienced first-hand the relative benefits and costs of large-scale telecommuting. Some organizations' benefit-cost calculus may have caused them to revert back to predominantly in-person work, with companies such as Tesla offering famous examples. Nonetheless, as transition cost and uncertainties were a major factor in organizational resistance to telecommuting adoption prior to COVID-19 (Prager, Rhoads & Martinez, 2022), it is likely that the sudden cultural change induced by the pandemic will have caused organizations to increase adoption on average.

3. Methodology

The research team for this study collected primary data from state-level surveys administered to employees and also conducted targeted interviews for employers. Secondary data were also analyzed from national, state, and regional sources. The study received the approval of the CSUDH Institutional Review Board (IRB) on September 8, 2021 (Subject: 22-015 "California Telecommuting Study").

Section 3.1 explains the state-level survey design, Section 3.2 explains the state-level interview design, and Section 3.3 presents the methodology used to analyze telecommuting behavior using regression analyses.

3.1 State-Level Survey Design

Since there was a lack of data about telecommuting during the COVID-19 pandemic, we conducted state-level surveys using a crowd-sourced online platform (i.e., Amazon Mechanical Turk) to obtain representative samples across California from employees' perspectives. Amazon Mechanical Turk can effectively and reliably retrieve internet-based samples through fast and cost-friendly online surveys (Bentley et al., 2017). More inspiring, the data quality is comparable to traditional large surveys and even outperforms some third-party survey companies (Kees et al., 2017). Inclusion of pre-built qualifications when recruiting participants (e.g., setting up Masters Qualification and thresholds based on better performance on previously similar tasks) could narrow down the targeted respondents and ensure data with higher quality (Peer et al., 2014). This approach can also be leveraged to engage a large pool of survey respondents and cover various geographic areas of interests.

We set up pre-built qualifications when recruiting participants. Human Intelligence Task (HIT) is a single, self-contained, and virtual task that an Amazon Mechanical Turk Worker (at least 18-year-old with a valid Amazon account) can work on. For example, we included only survey respondents with at least an 80% HIT approval rate; the HIT approval rate represents the proportion of completed tasks that are approved by other requesters (i.e., the people who release Amazon Mechanical Turk tasks; in this case, we are the requesters, and our respondents are the Workers). To limit the geographic location based on the project goal, we allowed only respondents with a registered address in California. We launched the survey on September 22, 2021, with a goal of retrieving 2,000 survey respondents.

The survey was designed to account for telecommuting patterns before and during, as well as preferences after the COVID-19 pandemic across California (see Appendix A). We defined "before COVID-19" as before December 2019, and we defined "during COVID-19" as the period after December 2019 up to the time when the survey was taken (September to November 2021). The intention was to improve understanding of the impacts, barriers, and strengths of telecommuting. The survey consisted of four sections:

1) Getting around: this section focused on travel patterns (e.g., modes of travel, commute mileage, commute time, and travel experience).

2) Your work: this section focused on work experience (e.g., working status, location, industry, size of workplace, hours, and telecommuting experience and preference).

3) Surrounding environment: this section focused on living condition (e.g., home location, size, moving condition, and number of people).

4) About you: this section focused on socioeconomic status (e.g., gender, age, race/ethnicity, education, household income, marital status, children, car ownership, and health).

To ensure data quality, two screening questions were included in the original survey. For example, we asked survey respondents to select "somewhat agree" and "strongly agree" here to ensure that they have read the questions carefully. Additionally, the number of answers marked "Not Applicable" was scrutinized; that is, responses with all answers marked "Not Applicable" would be excluded.

3.2 State-Level Interview Design

After reviewing the literature related to telecommuting and flexible working practices during the pandemic, we developed a questionnaire for the structured in-depth interviews (see Appendix B). The questionnaire consists of two parts. The first part of the questionnaire includes the interviewee's basic information such as experience in the industry and position in the company. The second part includes questions about respondents' flexible working practices before and during the pandemic, as well as preferences for the future.

1) The current policy of flexible working practices.

2) The percentage of flexible workers and the profile of remote workers.

3) The success and difficulties of training remotely, improving productivity, and maintaining company culture through remote work.

4) The changes in the policy of flexible working practices over the next 12 months.

5) The impact of COVID-19 variants on policies pertaining to flexible working practices.

6) The impact of local, state, or federal COVID-19 mandates on remote work policies.

7) The changes in real estate strategies over the next 12 months.

8) The changes regarding hiring policy.

9) The impact of telecommuting on the workforce in the long run.

We deployed snowball sampling to recruit experts for this study. First, in order to reflect a more generalized pattern across California, we listed the top ten industries by the number of employees in California: (1) utilities, (2) transportation and warehousing, (3) wholesale and retail trade, (4) educational services, (5) health care and social assistance, (6) professional and business services, (7) federal, state, and local government, (8) finance and insurance, (9) entertainment and recreation, and (10) manufacturing.

Next, the Office of CSUDH Alumni Relations, the South Bay Workforce Investment Board, and the California Transportation Commission helped us reach out to experts from the ten industries. An honorarium was offered to interviewees in the elicitation process to compensate them for their time. After the respondents showed interest, we sent out the first part of the questionnaire to acquire information about their background and industry experience to verify their qualifications. Then, we sent out the full version of the questionnaire, to be completed based on their expertise one week before the interview. During the interview, the interviewees elaborated on their responses in the questionnaires. After the interviews, we asked interviewees to facilitate contact with other experts. Eventually, we successfully recruited 28 industry experts (Table 3).

Table 3. Profile of Experts Interviewed

Industry	Count	Average of Years in the Industry	Positions
Utility	2	18	Sr. Advisor, Division General Manager
Transportation and Warehousing	6	20	Principal Transportation Planner, Senior Manager, Director, Office Chief, Senior HR Business Partner, Deputy Director of Planning and Programming
Wholesale and Retail Trade	1	32	Regional Traffic Manager
Educational Services	2	12	Director, Office Assistant
Health Care and Social Assistance	2	11	Project Manager, Manager
Professional and Business Services	2	12	Founder and CEO, Business Operations Analyst
Federal, State, and Local Government	6	15	Senior Program Manager, Senior Regional Planner, Program Analyst, Program Analyst, Deputy Executive Director, Program Coordinator
Finance and Insurance	2	8	SVP Finance, Manager
Entertainment and Recreation	3	6	Director, Event Service Manager, Chief Marketing Officer
Manufacturing	2	24	Regional HR Manager, Sr. Manager of Human Resources
Total	28	15	

3.3 Regression Models

The statistical analyses discussed below aim to answer a series of research questions generated through a combination of literature review and reflection on the dynamics of the COVID-19 pandemic and commuting behavior. This section firstly poses the research questions, secondly proposes a literature-informed general model to explain the relationship between the COVID-19 pandemic and commuting behavior (including telecommuting), and finally offers details about the levels of analysis and statistical techniques used with respect to available data for each research question.

The following research questions guide this statistical analysis:

R1: To what extent did the COVID-19 pandemic impact telecommuting and other commute modes in California?

- R1a: Can we establish a causal relationship between the COVID-19 pandemic and rates of telework?
- R1b: Similarly, is there a causal relationship between COVID-19 and other commute modes?
- R1c: Are these relationships still present after controlling for factors such as unemployment rates, weather, and prices?
- R1d: Did government policy impact travel behavior, or was public risk perception of COVID-19 a more dominant factor?
- R1e: What can spatial and locational variability—across California counties or places—tell us about the factors influencing telecommuting before and during the COVID-19 pandemic?

R2: What will the future of telecommuting look like in California?

- R2a: What can pre-COVID-19 telecommuting and commute behaviors—especially across California counties and places—tell us about the future of telecommuting?
- R2b: Did the significant increase in telecommuting during COVID-19 lead to a sustained shift in commute behaviors?
- R2c: As the pandemic transitions into an endemic stage, have we reached a "new normal" in telecommuting behavior?

When considering these questions, a general explanatory model of demand-side factors influencing telecommuting adoption and usage is derived from the literature (Caulfield, 2014; Drucker & Khattak, 2000; Eom et al., 2016; Loo & Wang, 2018; Mannering & Mokhtarian, 1995; Pouri & Bhat, 2003; Sarbu, 2015; Sener & Bhat, 2011; Walls et al., 2007). As discussed earlier in this report, Eom et al. (2016) provided the most comprehensive conceptual framework within this literature (Figure 3), and Table 4 uses and expands on this framework to search for relevant data by California city and county.

Figure 3 presents a general explanatory model of the relationships between the presence of COVID-19—as represented through numbers of cases, hospitalizations, and deaths—and commuting decisions, which involve workplace travel across numerous transportation modes and

telecommuting patterns. As shown in Figure 1, prior to the COVID-19 outbreak, telecommuting rates were growing slowly but steadily, and technological improvements and occupational shifts were clashing with managerial and executive resistance. These factors are not explicitly stated in Figure 3 but are summed up through "workplace culture," which was slowly shifting in the direction of pre-pandemic telecommuting trends.

The COVID-19 pandemic provided a major shock to the prior workplace and behavioral factors that influenced telecommuting rates. Telecommuting increased from 5% (full-time workers) and 15% (part-time workers) to a ceiling of between 37% and 56% (estimates based on telecommuting compatibility by occupation; Dey et al., 2020; Dingel and Neiman, 2020) in the first lockdown period (March to May 2020). Other survey-based research reports increases in telecommuting of 22%–25% (Dey et al., 2020) to 35% (Brynjolfsson et al., 2020).

However, it is unclear whether the telecommuting increases during the early days of the pandemic were the result of major policy changes, behavioral factors, or other changes, as set out in Figure 3. During the early pandemic period, major public health policies were introduced: lockdowns were enacted, working from home was recommended and even required in some countries, and school and economic sector closures were enforced. These public health signals flowed alongside data on COVID-19 cases, hospitalizations, and deaths, into the complex structures of risk perception and behavior within society.

The theory of the social amplification of risk suggests that societal functions such as mass media and social media—both of which are increasingly plural, polarized, and politicized—combine with social networks to create flows of risk information that are divergent from the original evidence or expert opinion. As such, information and policy around the COVID-19 pandemic resulted in quite different behavioral responses with respect to political opinions, media consumption, and social media networks. For example, studies suggest that conservatives and conservative-leaning regions tend to undervalue the seriousness of COVID-19 and be less likely to follow public health recommendations, while liberals and liberal-leaning regions tend to overestimate the risk of COVID-19 and be more likely to both adopt and maintain public health recommendations (Alsan et al. 2020; Bursztyn, 2002; Makridis & Rothwell, 2020) Similarly, there are likely to be different attitudes toward returning to workplaces and avoiding telecommuting because of the social amplification of risk.

There are also numerous confounding factors influencing telecommuting rates that are important to consider. Unemployment increased to unprecedented levels during the first lockdown period, decreasing workplace travel significantly. Furthermore, businesses and workers took advantage of numerous government assistance programs to soften the impact of public-health-required business and workplace closures. Even as the dynamics of the pandemic began to play out, with business rebounding and schools reopening, workplace and telecommuting decisions were influenced by other factors such as family and lifestyle decisions or constraints—e.g., moving or retiring—and transportation-related factors such as gas prices and perceived transit safety.

We base our analysis on several data sources, including data from Google's COVID-19 Community Reports, the California Employment Development Department, the U.S. Census Bureau, Coronavirus Media Monitor, the COVID-19 Government Response Tracker, and the CDC's COVID Data Tracker, among others (see Table 4 for detailed information on the independent variables used in the regression analysis). Guided by the literature-informed model presented above, we collected data on COVID-19 cases, hospitalizations, deaths, and vaccinations to try to analyze their potential impact on telecommuting and other transportation modes in California. Our unit of analysis, driven by the availability of data, is the county. California has 58 counties, but we were able to collect significant data only for 56 counties. The Alpine and Sierra counties were excluded due to limited data available.

For our main analysis, the dependent variables are based on Google's COVID-19 Community Reports daily data (https://www.google.com/covid19/mobility/). These county-level data capture daily changes in the number or duration of trips to different types of places compared to a baseline period before the pandemic (median values between January 3 and February 6, 2020). The different travel categories are Retail & Recreation, Grocery & Pharmacy, Parks, Transit Stations, Workplaces, and Residential. As such, a value of -7 for a particular category and date would represent a 7% reduction in the number or duration of trips compared to the baseline measure.

COVID-19 data used as control variables were obtained from the California Department of Public Health's COVID-19 Vaccine Progress Dashboard and the CDC's COVID Data Tracker. These data contain several statistics related to the COVID-19 pandemic, including the number of cases, hospitalizations, deaths, the number and type of vaccines administered, and even some of the characteristics of the people receiving those vaccines.

To try to capture the different government policy factors that could have influenced commuting behavior throughout the pandemic, we include indices collected by the COVID-19 Government Response Tracker from the Blavatnik School of Government at the University of Oxford (https://www.bsg.ox.ac.uk/research/research-projects/covid-19-government-response-tracker). These researchers constructed several indices that capture different state governments' responses to the COVID-19 pandemic, all operationalized based on public policies regarding mandated closures, health system policies, vaccination policies, and economic support programs. From the Blavatnik School's indices, we include the Stringency Legacy index, which captures the degree of strictness in California's government policies that aimed to restrict people's travel behaviors across various factors such as school and workplace closures, restrictions on public events and private gatherings, stay at home orders, and other domestic and international travel restrictions, as well as the Economic Support index, which captures information about state government policies regarding economic support and debt relief in response to the pandemic.

We also include indices from the Coronavirus Media Monitor, which tracks U.S. news and tries to capture overall public sentiment on the COVID-19 pandemic, conveyed as the overall sentiment presented in the news (https://www.ravenpack.com/solutions/research/coronavirus-

media-monitor). As such, these indices reflect more the sentiment of journalists than the public. The Panic Index measures the level of COVID-19 pandemic news that refers to panic or hysteria, and the Sentiment Index measures the overall sentiment presented in COVID-19-related news using a content analysis approach. The former ranges from 0 to 100, with higher values representing higher levels of panic or hysteria perception in the news, while the latter ranges from -100 to 100, where negative values represent an overall negative sentiment in the news, positive values represent an overall positive sentiment, and 0 is neutral.

To control for other factors that might influence travel behavior during the pandemic, we also include the average monthly rainfall, median home prices, percentage of non-farm employment and public-sector employment, and the percentage of households with access to high-speed internet.

Considering the available data, our main statistical analysis was performed using two different methods. First, we used Ordinary Least Squares regressions to analyze travel data at four specific periods corresponding to significant developments throughout the COVID-19 pandemic period and using several covariates described before. (Please see Figures 38 and 39 in the results sections.) Second, we analyzed the travel data using monthly average values by county having a total of 24 observations per county (February 2020 – January 2022); we did so using Balanced Panel Data regressions. This method allows us to obtain consistent estimators of the different control variables in the presence of omitted variables (Wooldridge, 2001). These potential county-level omitted variables might be correlated or uncorrelated with the control variables and they might be fixed or time-variant. A Hausman test can be used to determine whether a fixed-effects or random-effects model is more appropriate. Provided the assumptions are satisfied, this method allows us to give the estimates of the control variables a causal interpretation concerning travel behavior.

Figure 3. General Explanatory Model of the Relationship between the COVID-19 Pandemic and Commuting Behavior

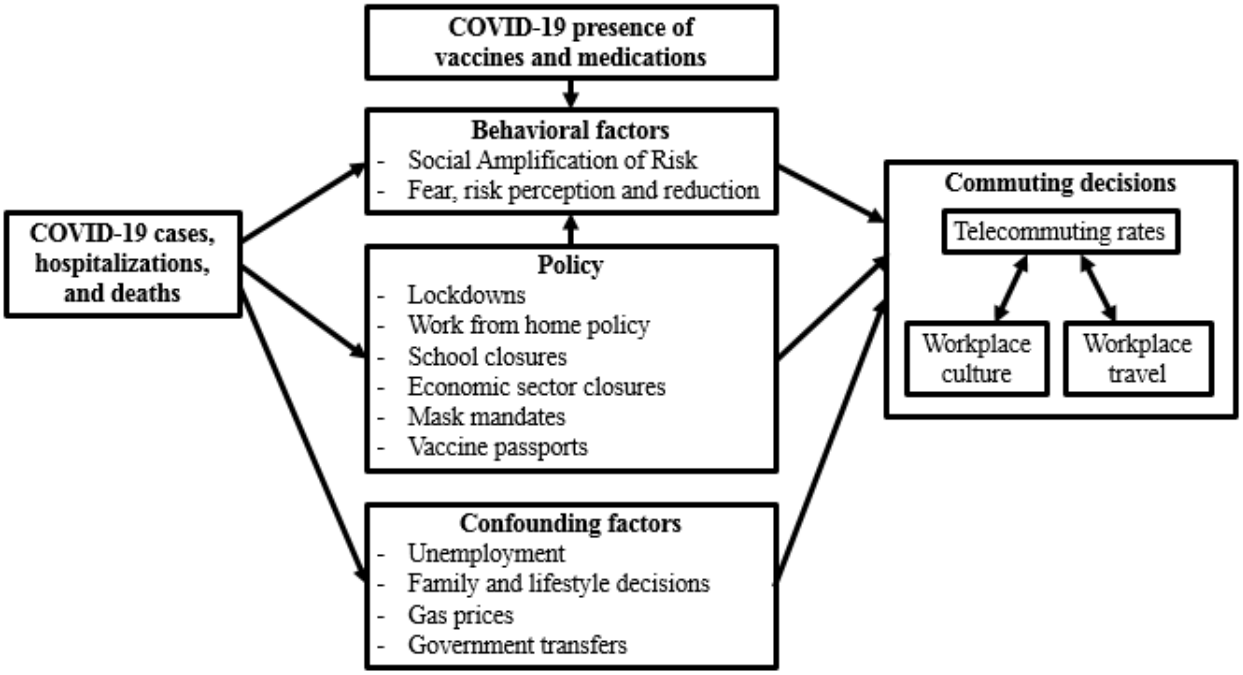


Table 4. Data Sources for Regression Analysis Independent Variables

Literature Review Factors	Indicator	Year	Spatial Resolution	Source
Gender	Gender ratio	2019		https://data.census.gov/cedsci/
Age	Median age of total population	2019	County & city	https://data.census.gov/cedsci/
Marital Status	Percentage of men/women never married	2019		https://data.census.gov/cedsci/
Income	Median household/family income	2019	County & city	https://data.census.gov/cedsci/
Job tenure	Percent of adults in labor force, labor force, employment, unemployment, and unemployment rate	Monthly 2019–2021	County	http://www.labormarketinfo.edd.ca.gov/cgi/dataanalysis/areaselection.asp?tablename=labforce
Organization type	Percent population in management, service, manufacturing, information, computing, and healthcare	2019		https://data.census.gov/cedsci/
Position				https://data.census.gov/cedsci/
Government employment	Employment by industry			https://data.census.gov/cedsci/
Job category	Percent of people employed who are wage and salary workers (private)	2019		https://www.census.gov/quickfacts/fact/dashboard/CA,US
Relocation of organization	Percent of inbound vs. outbound business relocations	2021		https://catalog.data.gov/dataset/listing-of-active-businesses
Home conditions				https://data.census.gov/cedsci/

Literature Review Factors	Indicator	Year	Spatial Resolution	Source
Education	Percent of 25 years or older with HS, BA, or advanced degree	2019, 2021		https://data.census.gov/cedsci/
Urban/rural	Population by county, attribute classification	2013		https://www.census.gov/programs-surveys/geography/guidance/geo-areas/urban-rural.html
Technological conditions	FCC data by state or by census block (FIPS code); December 2020 is latest, updated every 6 months Useful variables are: Technology of transmission - DSL, Cable Modem, Fiber, etc. (various options). Consumer (0 or 1), whether household broadband is offered in the block or not. Max downstream speeds. Max upstream speeds. Business (0 or 1), whether business broadband is offered in the block or not.	2019	County & city	https://broadbandmap.fcc.gov/#/
Social conditions	Percentage population below poverty line, receiving social assistance, and food stamps	2019	County & city	https://data.census.gov/cedsci/
Cost of commuting	Mean travel time, percentage mode of transportation to work, and percentage work outside county of residence	2019		https://nhts.ornl.gov/

Literature Review Factors	Indicator	Year	Spatial Resolution	Source
Cost of business trips	Count of passenger service airports in California	2021		https://ourairports.com/countries/US/CA/airports.html
Expected work productivity	College completion level	2019		https://data.ers.usda.gov/reports.aspx?ID=17829
Institutional and technological support				
Burden of supporting family	Percentage of household married with children under 18	2019		https://data.census.gov/cedsci/
Land use diversity/mix		2010	Block group	https://www.epa.gov/smartgrowth/smart-location-mapping#SLD
Land use density (residential and employment density)		2010	Block group	https://www.epa.gov/smartgrowth/smart-location-mapping#SLD
Number of households that own one automobile		2010	Block group	https://www.epa.gov/smartgrowth/smart-location-mapping#SLD
Employment-related variables by each job category		2010	Block group	https://www.epa.gov/smartgrowth/smart-location-mapping#SLD
Total road network density		2010	Block group	https://www.epa.gov/smartgrowth/smart-location-mapping#SLD
Transit access		2010	Block group	https://www.epa.gov/smartgrowth/smart-location-mapping#SLD
Destination accessibility		2010	Block group	https://www.epa.gov/smartgrowth/smart-location-mapping#SLD

Literature Review Factors	Indicator	Year	Spatial Resolution	Source
Walkability index		2010	Block group	https://www.epa.gov/smartgrowth/smart-location-mapping#SLD
Relocation of people		2021	Block group	https://www.gstatic.com/covid19/mobility/2021-11-19_US_California_Mobility_Report_en.pdf
Resilience		2018		https://www.atsdr.cdc.gov/placeandhealth/svi/index.html
California Healthy Places Index	Percentage of the population living within a half-mile of a park, beach, or open space greater than 1 acre	2012	Census tract + zip code	https://healthyplacesindex.org/data-reports/
California Healthy Places Index	Population-weighted percentage of the census tract area with tree canopy	2011	Census tract + zip code	https://healthyplacesindex.org/data-reports/
California Healthy Places Index	Percentage of the urban population residing less than 1/2 mile from a supermarket/large grocery store, or the percent of the rural population living less than 1 mile from a supermarket/large grocery store	2015	Census tract + zip code	https://healthyplacesindex.org/data-reports/
California Healthy Places Index	Gross retail, entertainment, and education employment density (jobs/acre) on unprotected land	2010	Census tract + zip code	https://healthyplacesindex.org/data-reports/
California Healthy Places Index	Percent of occupied housing units occupied by property owners	2015	Census tract + zip code	https://healthyplacesindex.org/data-reports/
California Healthy Places Index	Percent of households with kitchen facilities and plumbing	2014	Census tract + zip code	https://healthyplacesindex.org/data-reports/

Literature Review Factors	Indicator	Year	Spatial Resolution	Source
California Healthy Places Index	Percent of households with access to an automobile	2011–2015	Census tract + zip code	https://healthyplacesindex.org/data-reports/
California Healthy Places Index	Percent of workers (16 years and older) who commute to work by transit, walking, or cycling	2011–2015	Census tract + zip code	https://healthyplacesindex.org/data-reports/
California Healthy Places Index	Percent of population aged 20–64 who are employed	2011–2015	Census tract + zip code	https://healthyplacesindex.org/data-reports/
California Healthy Places Index	Percent of the population with an income exceeding 200% of federal poverty level	2011–2015	Census tract + zip code	https://healthyplacesindex.org/data-reports/
California Healthy Places Index	Percent of children in married-couple family households or one parent with unmarried partner family households	2011–2015	Census tract + zip code	https://healthyplacesindex.org/data-reports/
California Healthy Places Index	Mean of summer months (May-October) of the daily maximum 8-hour ozone concentration (ppm), averaged over three years (2012 to 2014)	2012–2014	Census tract + zip code	https://healthyplacesindex.org/data-reports/
California Healthy Places Index	Annual mean concentration of PM2.5: average of quarterly means (μ/m3) over three years (2012 to 2014)	2012–2014	Census tract + zip code	https://healthyplacesindex.org/data-reports/
California Healthy Places Index	Spatial distribution of gridded diesel PM emissions from on-road and non-road sources for a 2012	2012	Census tract + zip code	https://healthyplacesindex.org/data-reports/

Literature Review Factors	Indicator	Year	Spatial Resolution	Source
	summer day in July (kg/day)			
Current telecommuting data (01/01/2020-04/20/2021)		2020–2021	County	https://data.covid.umd.edu/
COVID-19 Related Transportation Statistics		2019–2021	County	https://www.bts.gov/covid-19

4. Findings from State-Level Surveys

Our Amazon Mechanical Turk state-level survey process completed on November 9, 2021, and it resulted in 1,985 valid responses out of 2,000 responses; 15 responses were removed based on our screening criteria (e.g., not passing the screening questions or selecting "Not Applicable" to all questions). Below, we present a descriptive summary of the survey responses. To further unveil the inequity aspects of the telecommuting patterns and preferences across the region - an understudied topic in the literature, we stratified the survey responses based on gender, age, race/ethnicity, education, household income, work, marital status, number of children, number of cars, and overall health.

4.1 Descriptive Summary

Below, we present the descriptive analyses grouped according to the four major sections of the survey.

4.1.1 About You

Most of the respondents were white, fell in the 25–34 year age bracket, held a Bachelor's or undergraduate degree, and had a household income of $50,000–$74,999. Additionally, most of the respondents were full-time employed and married, with no children, 1 car, 3–4 people in the household, and very good overall health status (Table 5).

Table 5. Sociodemographic Information of Survey Respondents

Variable	Category	Percent
Gender	Female	48%
	Male	50%
Race	American Indian or Alaskan Native	3%
	Black/African American	10%
	Hispanic/Latino	17%
	Asian	16%
	Caucasian/White	60%
Age	18–24	11%
	25–34	43%
	35–44	24%
	45–54	12%
	55–64	8%
	65–74	1%
	75 or older	0%
Education	Bachelor or undergraduate	48%
	High school diploma or GED	8%
	Master	15%
	Professional degree or doctorate	4%
	Some college, or associate degree	23%
Income	< $25,000	12%
	$25,000–$34,999	13%
	$35,000–$49,999	11%
	$50,000–$74,999	27%
	$75,000–$99,999	17%
	$100,000–$149,999	10%
	$150,000–$199,999	4%
	> $200,000	3%
Work	Full-time employed	72%
	Part-time employed	17%
	Full-time student	6%
	Part-time student	5%
	Homemaker	3%
	Not working	5%
Marital status	Married	51%

Variable	Category	Percent
	Single	43%
	Divorced	4%
	Separated	1%
	Widowed	1%
Number of children	None	47%
	1	20%
	2	27%
	3	5%
	More than 3	2%
Number of cars	None	7%
	1	45%
	2	32%
	More than 2	17%
Health status	Excellent	23%
	Very good	38%
	Good	29%
	Fair	8%
	Poor	1%

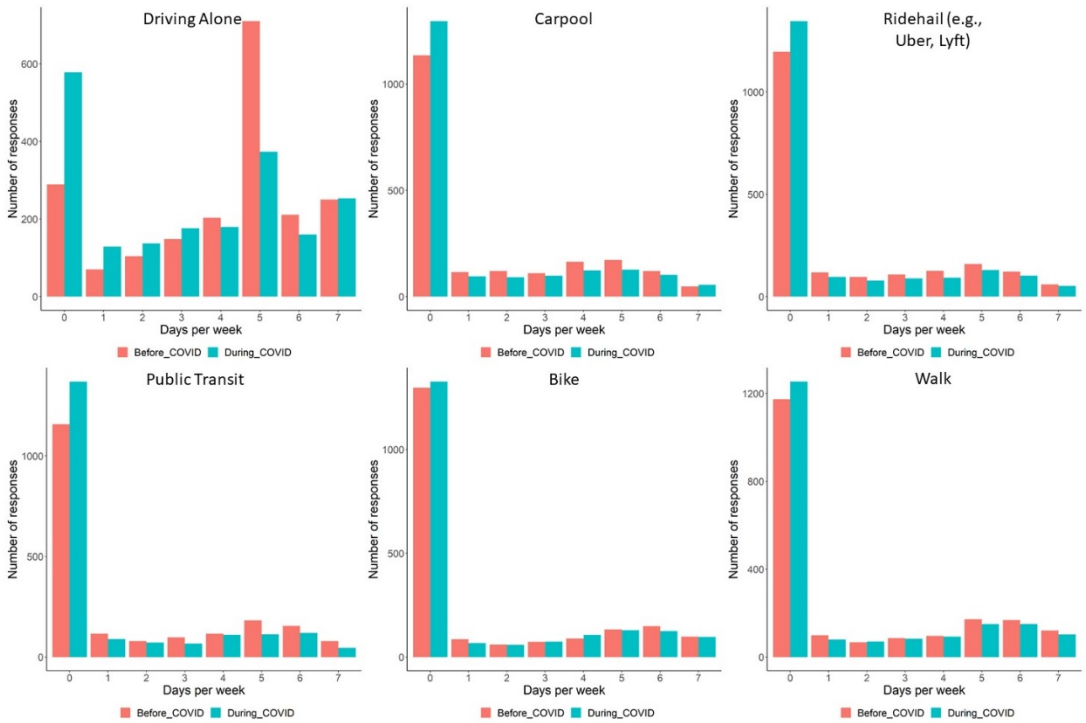
4.1.2 Getting Around

- There is a clear shift: the majority of respondents drove to work alone five days out of the week, which became zero days out of the week during the pandemic (Figure 4).

- During the pandemic, fewer respondents chose to carpool, ridehail, took public transit, walk, or use other transportation modes as compared to before COVID patterns. There was no obvious difference in biking before and during COVID (Figure 4).

- Before the pandemic, driving alone was the most popular commuting mode among the survey respondents when commuting on at least two days per week; for commuting demands below two days a week, driving alone was not the most popular mode. During the pandemic, the most popular transportation mode was driving alone if it was necessary to commute, regardless of the number of days per week (Figure 4).

Figure 4. Survey Responses: Commuting to Work by Different Modes



- Before COVID-19, most respondents had a commute distance of 6–20 miles and a commute time of 10–40 minutes. During the pandemic, the most common commute distance was 0–20 miles (Figure 5).

- Of all respondents, 28% somewhat agreed that they like biking and walking to work but the infrastructure (e.g., bike lane) makes it difficult. While 47% of respondents claimed that they have bus stops near their homes, 40% of respondents also found no bus stops near their homes. Further, 55% of respondents reported that traffic congestion has improved since the start of COVID (Figure 6).

Figure 5. Survey Responses: Commuting Distance and Time (One-Way)

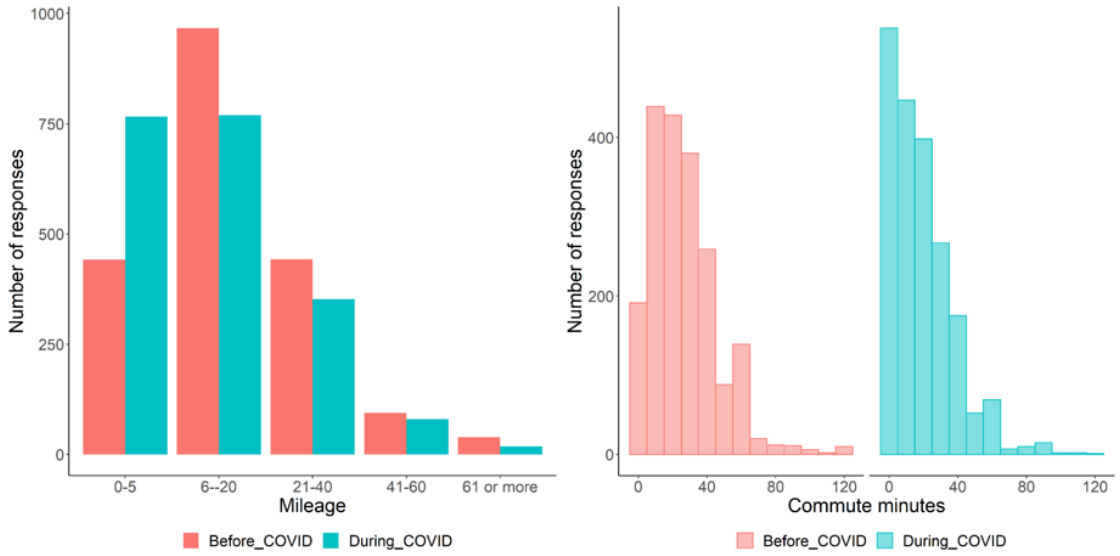
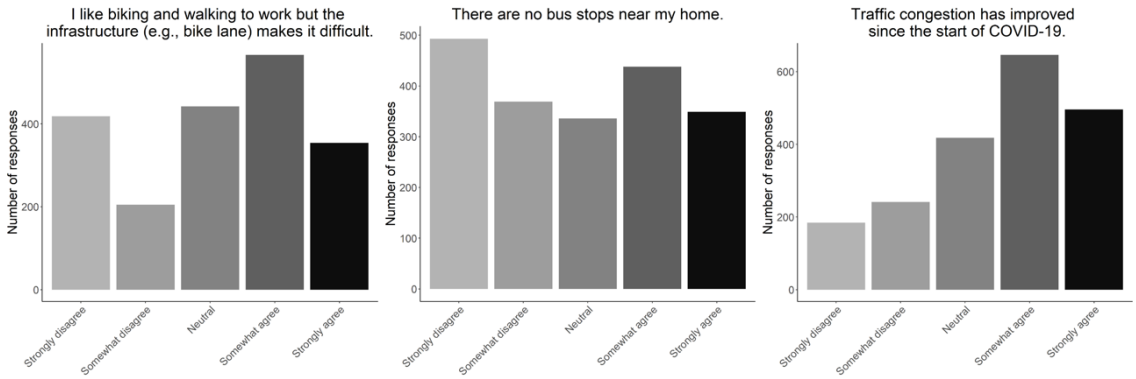


Figure 6. Survey Responses: Infrastructure and Travel



4.1.3 Your Work

- While most respondents lived and worked in Southern California and the Bay Area, respondents from 52 out of 58 counties in California were surveyed (Figure 7).

- The top five job categories whose employees were surveyed were information, educational services, health care, professional/business services, and an "other" category. Also, 70% of respondents worked in companies/organizations with 26–250 employees or more (Figure 8).

Figure 7. Number of Survey Respondents Working and Living in Each County

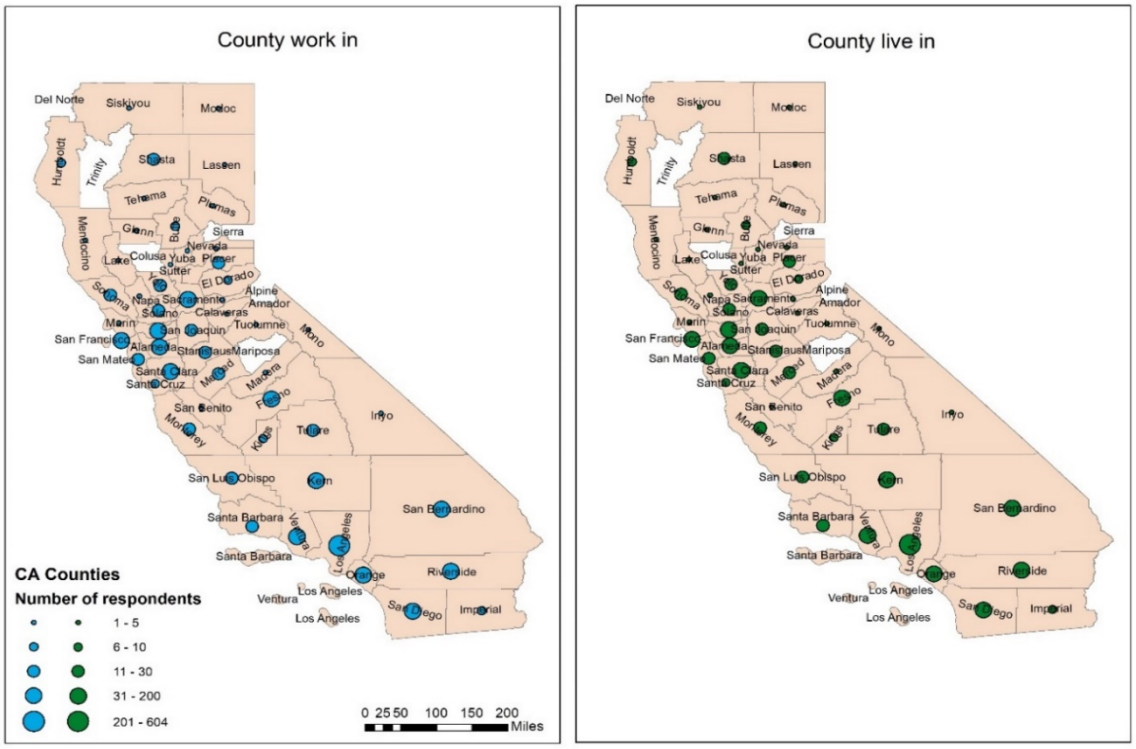
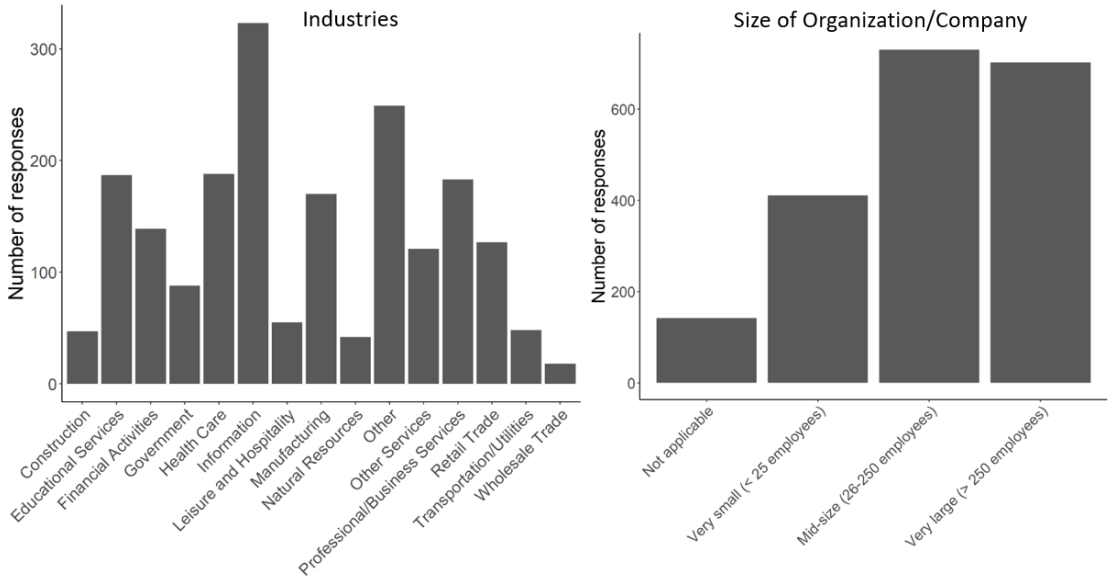


Figure 8. Survey Respondents' Work Industries and Organization/Company Size



- Of all respondents, 44% did not have better equipment and internet access to work from home during the pandemic as compared to the experience of working in the office before the pandemic. More than 50% of respondents had a dedicated workspace at home, had more flexibility to choose their own schedules, had received adequate training and support for telecommuting, improved their working performance when comparing to the working in the office experience before the pandemic but felt isolated and found it difficult to separate home and work life when working from home during the pandemic (Figure 9).

- In terms of workplace operations, 31% of respondents reported that their workplace had moved to partial work from home scenario, 20% reported a shift to permanent work from home, and 29% reported no change (Figure 10).

- In terms of preferred scenarios over the next three years, 25% of respondents found it ideal to fully work from home, and 25% of respondents found it ideal to work for three days in the office. Only 14% of respondents wanted to work fully in the office. Additionally, 43% of respondents expected no change in employers' office space, and 24% of respondents expected the office space of their workplaces to be reduced by more than 26% (Figure 11).

Figure 9. Survey Responses: Telecommuting Experience

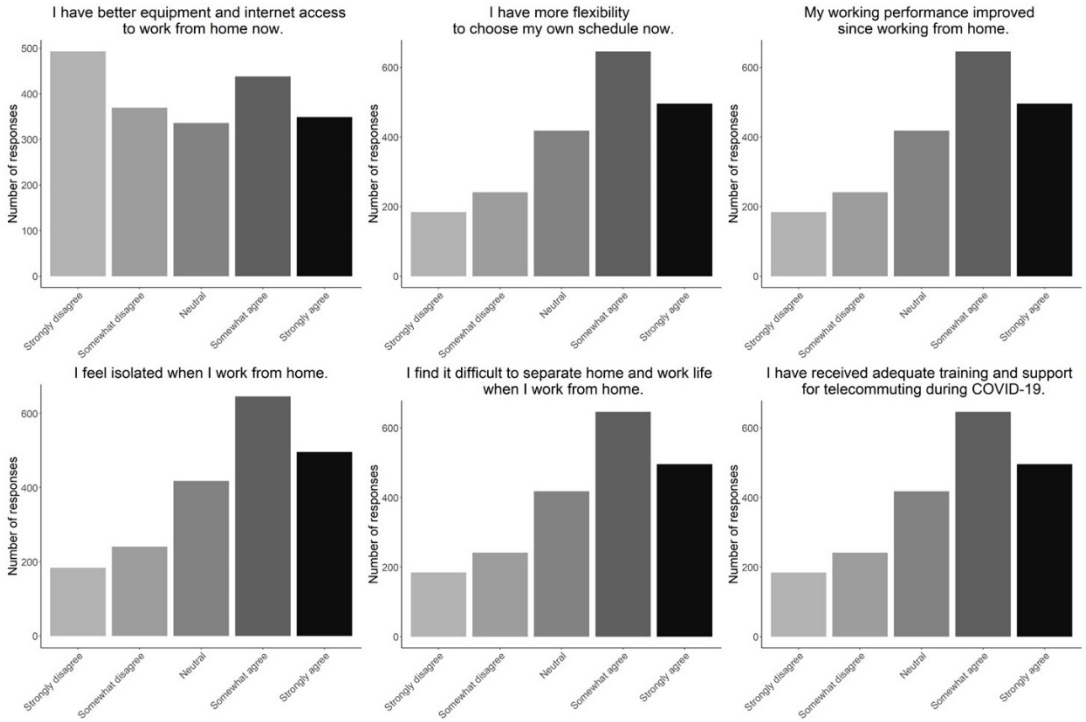


Figure 10. Survey Responses: Workplace Operations Changed During COVID-19

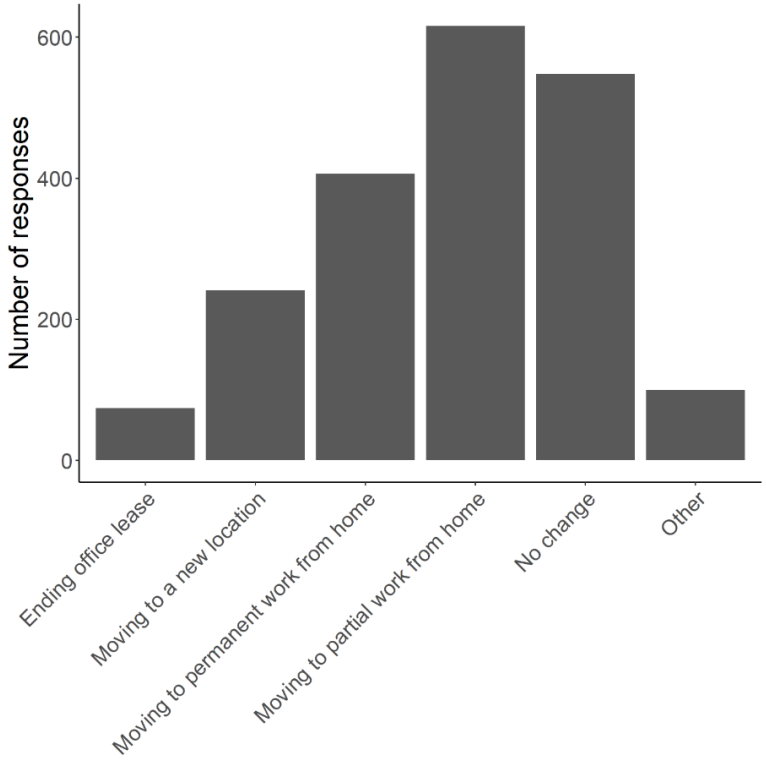
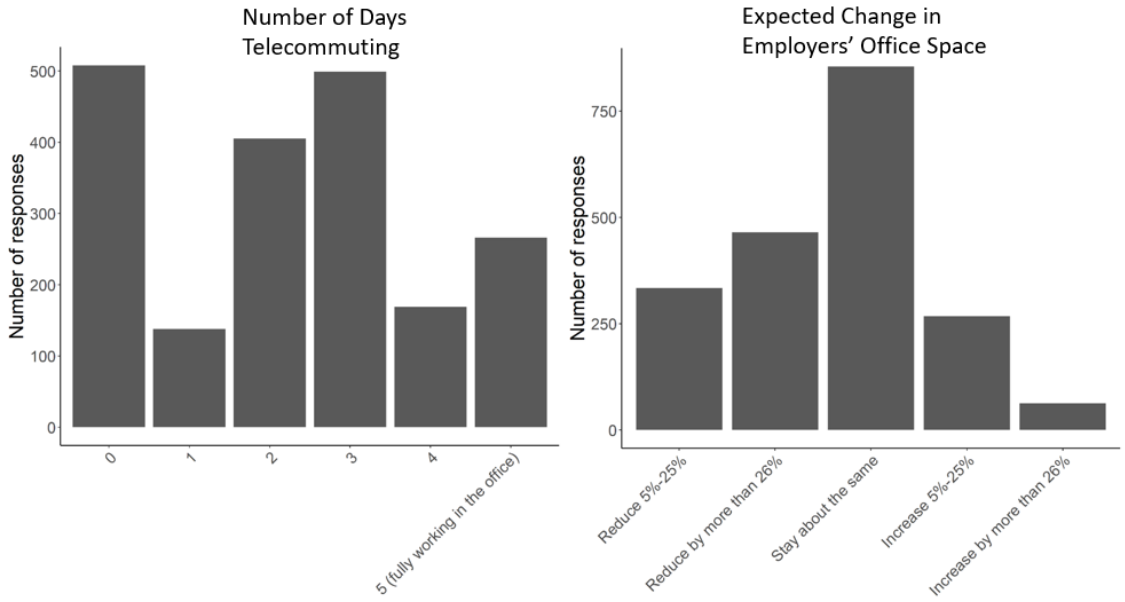


Figure 11. Survey Responses: Telecommuting Preference and Expectation Over the Next Three Years



4.1.4 Surrounding Environment

- Of all respondents, 50% of respondents owned their homes, 31% lived in homes that were 901–1,200 sq. ft., and 38% had moved residences during the pandemic.

- Out of the respondents who moved residences during COVID-19, 24% had more space in the new home and 29% respondents rented the new home.

- Opinions were divided on whether working from home affected the decision to move home.

4.2 Stratified Summary

Below, we summarize results from the stratified analyses based on the survey responses. In general, we found noticeable differences based on gender, age, race/ethnicity, education, household income, work, marital status, number of children, number of cars, and overall health. Below, we highlight the major findings by category in the goal of presenting information that may help inform polices on increasing telecommuting adoption and improving telecommuting experience for all people in California.

4.2.1 By Gender

- More women than men fully worked from home during the pandemic. When asked about their ideal work situation, women preferred fully working from home more than men over the next three years (Figure 12).

- A majority of men worked in information; women worked mostly in educational services, health care, and other industries (Figure 13).

Figure 12. Survey Responses by Gender: Commuting Preferences for the Future

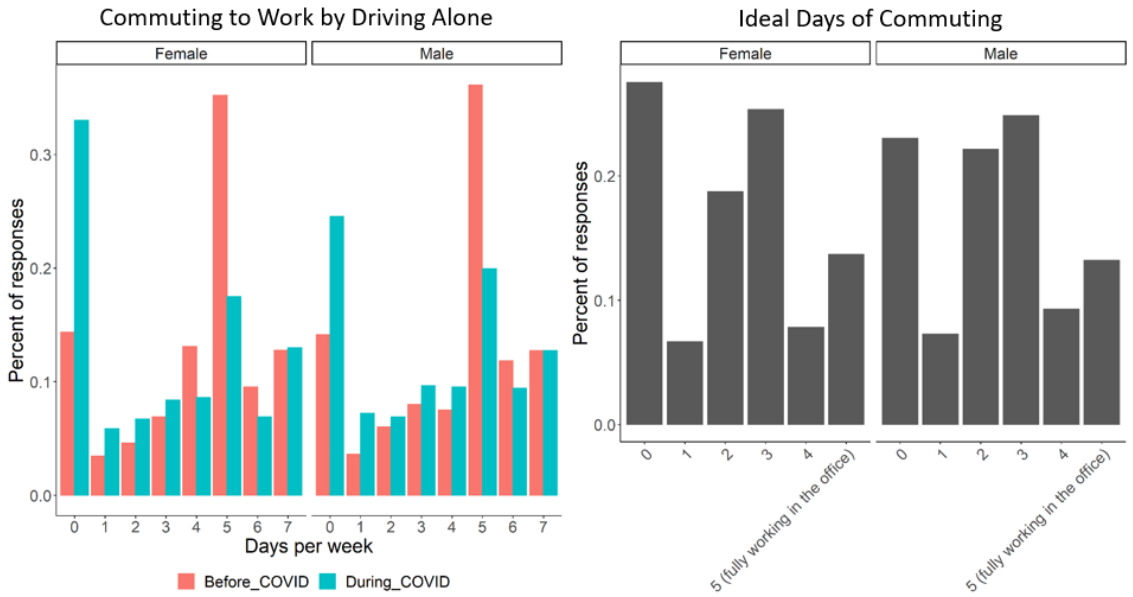
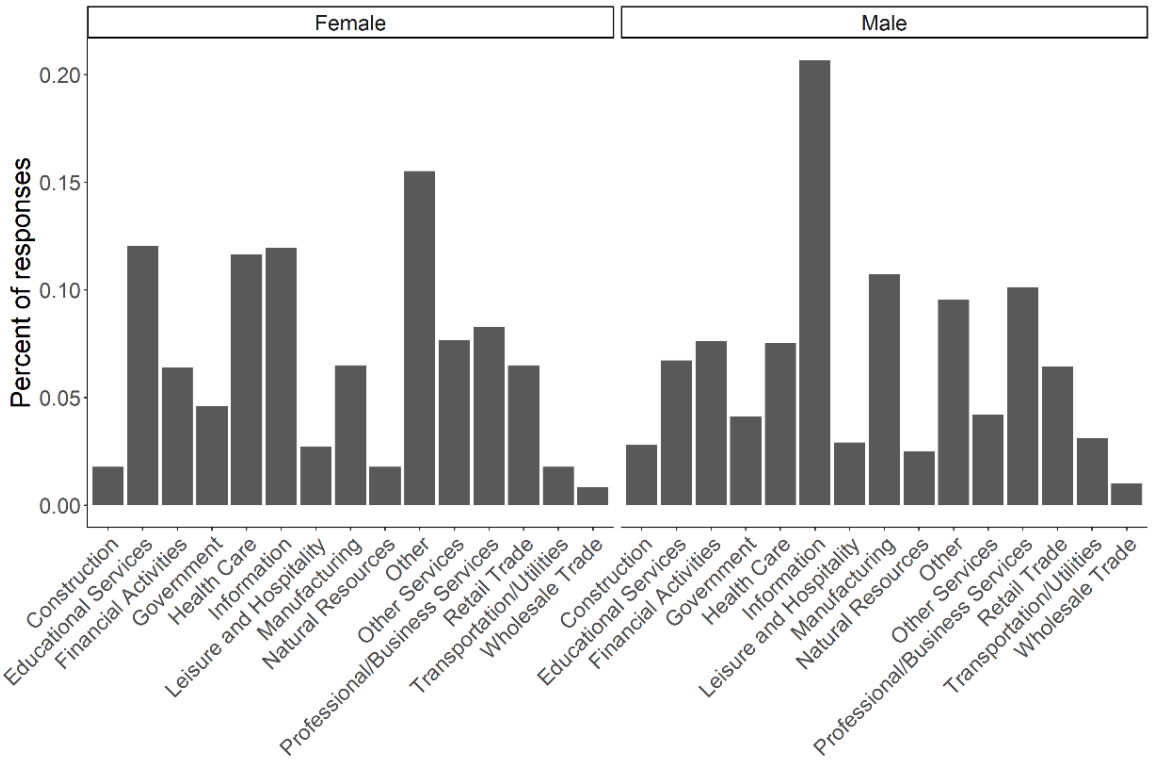


Figure 13. Survey Responses by Gender: Work Industries of Respondents



4.2.2 By Age

- During the pandemic, more younger respondents (i.e., 18-35-year-olds) did not drive alone to commute 5 days per week but still commuted for 1–4 days per week. In comparison, more older respondents (i.e., 45–64-year-olds) worked fully at home (Figure 14).

- Most younger respondents (i.e., 18–35-year-olds) did not have better equipment and internet access to work from home as compared to the experience of working in the office before the pandemic, which is in contrast with most older respondents (i.e., > 45 years old) (Figure 15).

- Among all respondents, only older respondents (i.e., 65–74-year-olds) strongly agreed that they felt isolated when working from home, while respondents of the rest age groups somewhat agreed with this statement (Figure 16).

- Most younger respondents (i.e., 18–24-year-olds) rented their home while more older respondents (i.e., > 35-year-olds) owned their home.

Figure 14. Survey Responses by Age: Commuting to Work by Driving Alone

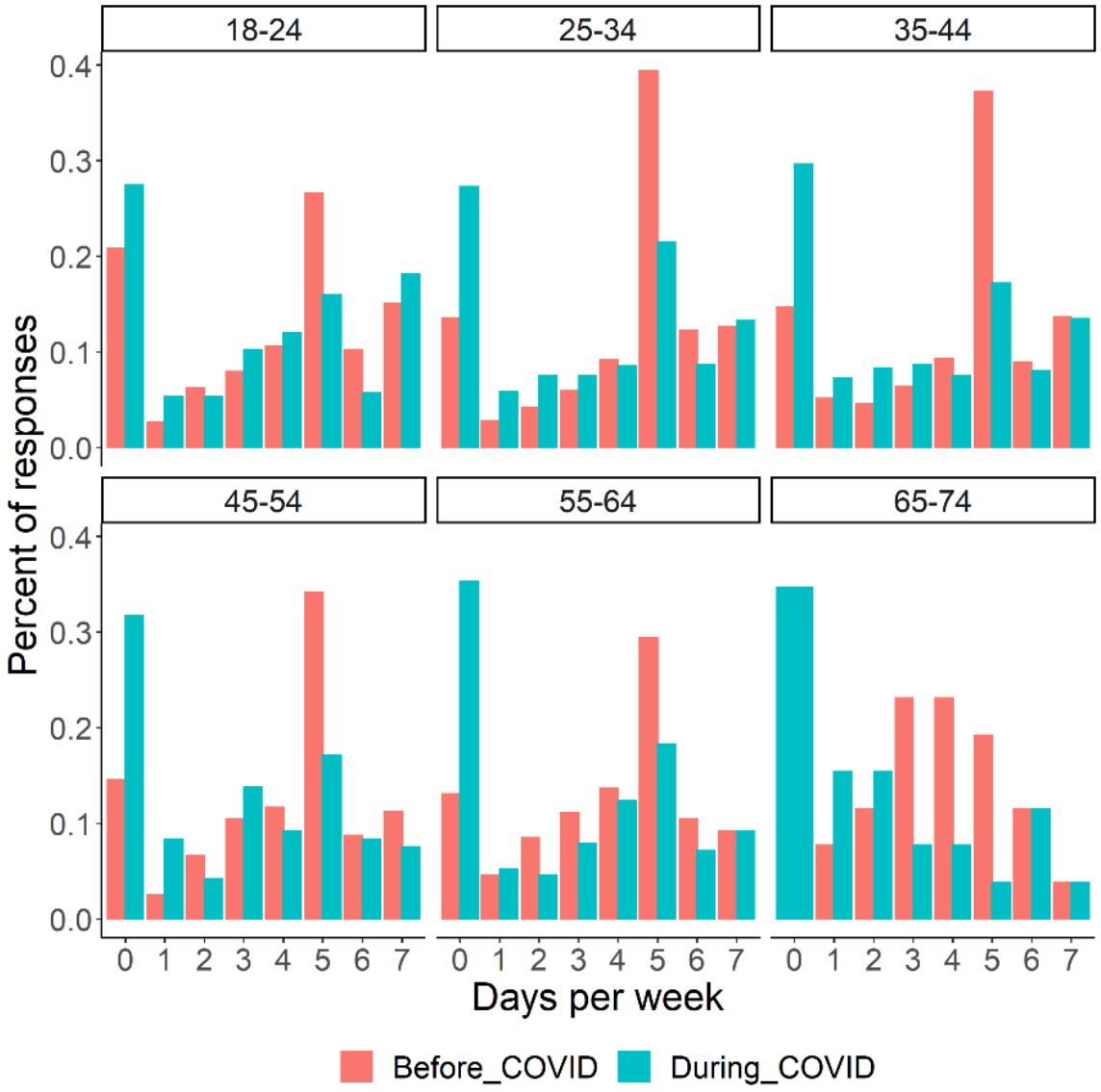


Figure 15. Survey Responses by Age: Equipment and Internet Access

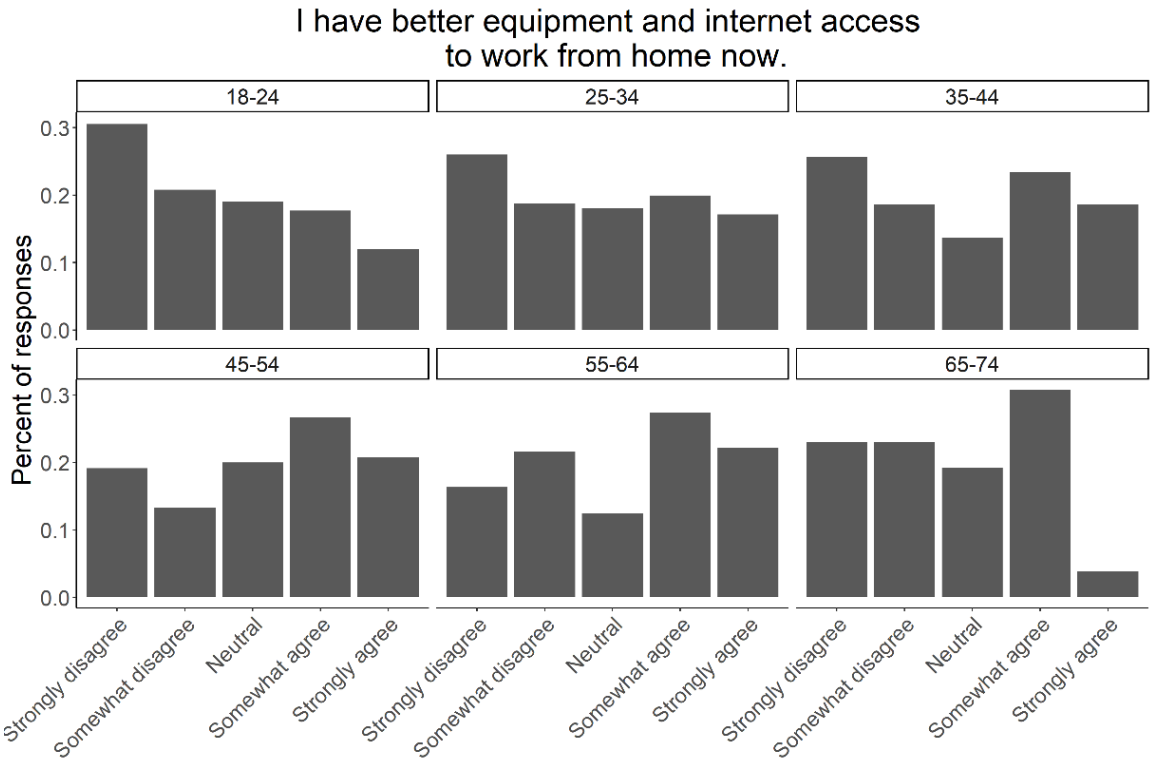
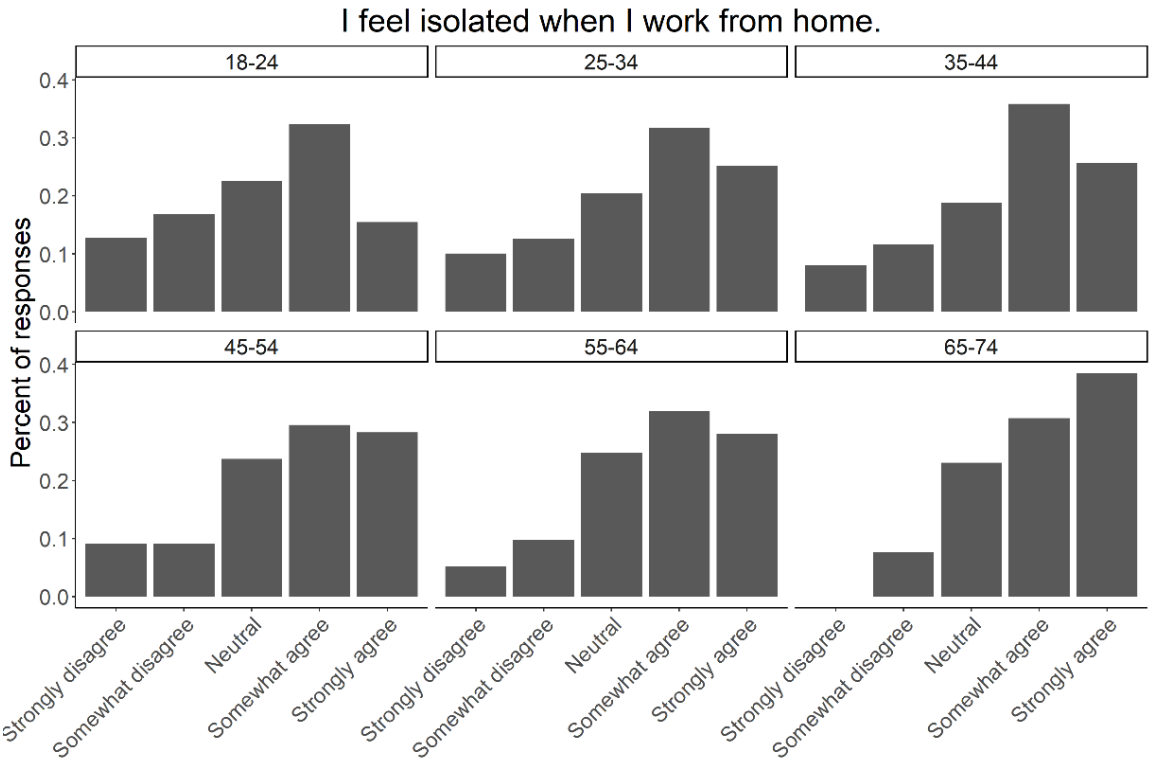


Figure 16. Survey Responses by Age: Feeling Isolated when Telecommuting



4.2.3 By Race

- Hispanic/Latino and Asian respondents preferred fully working from home than others over the next three years (Figure 17).
- Most Asian and Hispanic/Latino respondents did not work in a management position (Figure 18).
- Most Black/African American and Hispanic/Latino respondents did not have better equipment and internet access to work from home during COVID-19 as compared to the experience of working in the office before the pandemic (Figure 19).
- Most Black/African American respondents felt isolated and found it difficult to separate home and work life when working from home (Figures 20 and 21).
- Most Caucasian/White respondents owned a home whereas Asian, Black/African American, and Hispanic/Latino respondents rented.

Figure 17. Survey Responses by Race: Ideal Days of Commuting for the Future

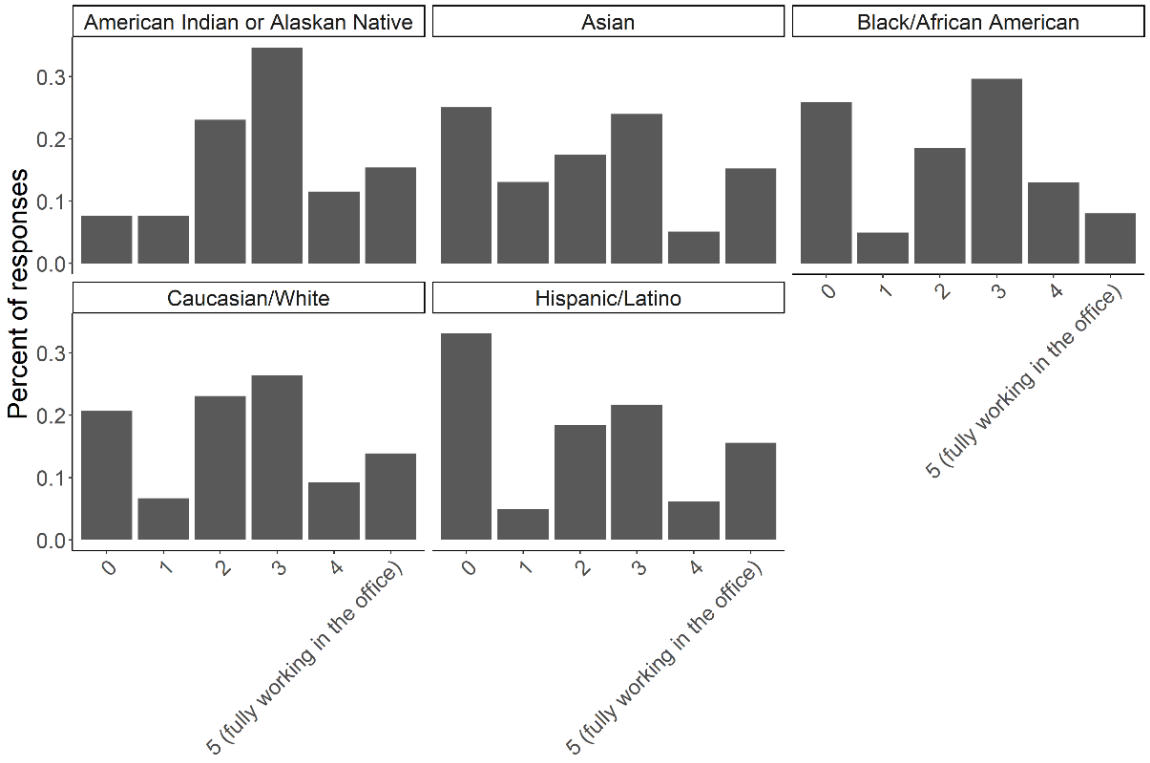


Figure 18. Survey Responses by Race: Respondents Working in a Management Position

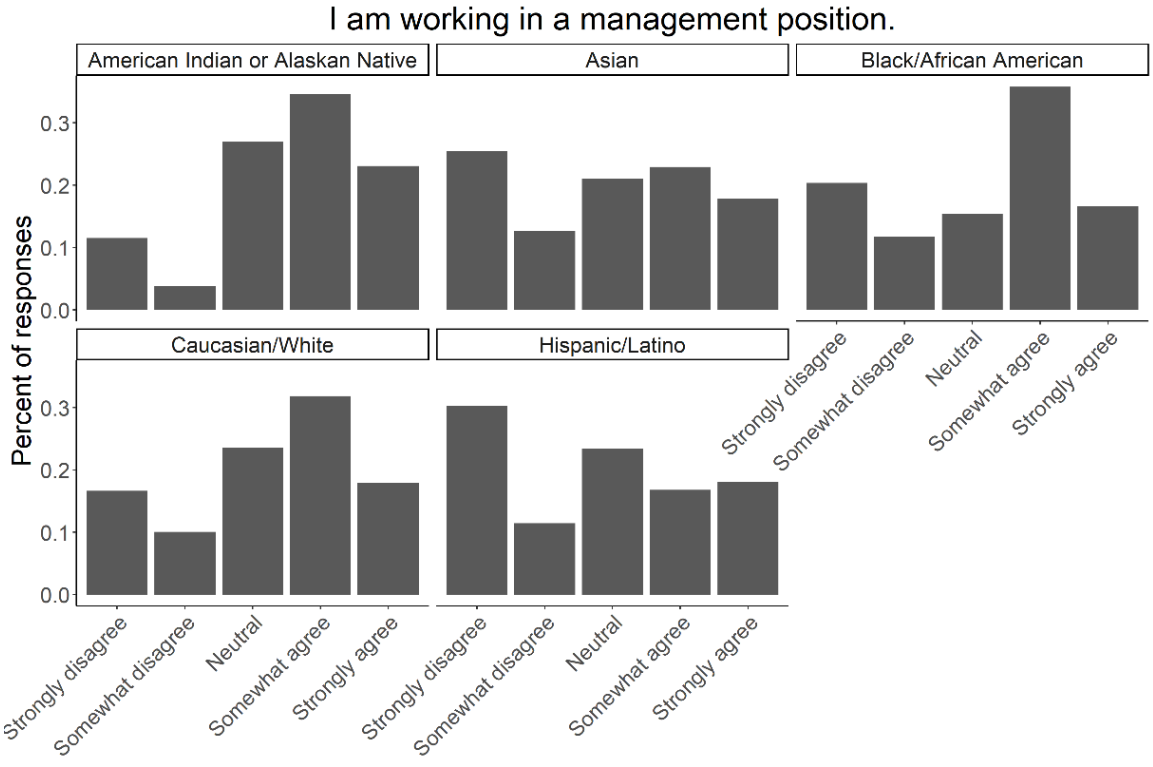


Figure 19. Survey Responses by Race: Equipment and Internet Access

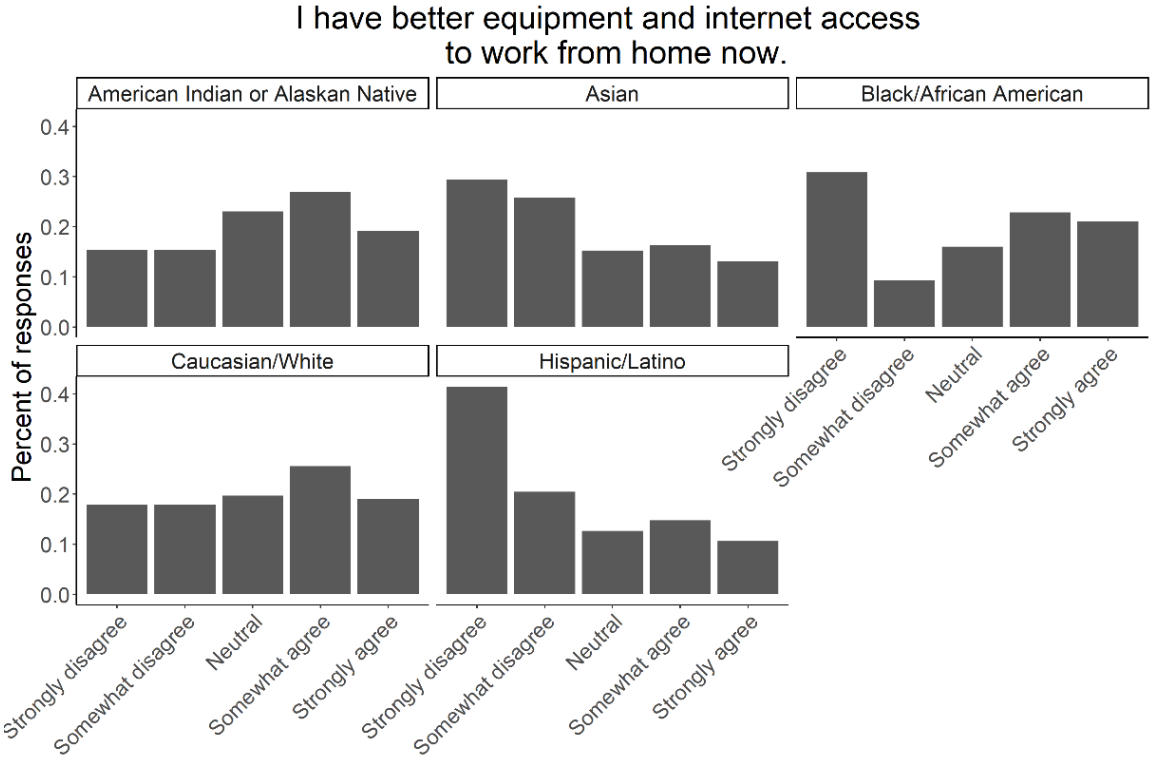


Figure 20. Survey Responses by Race: Feeling Isolated when Telecommuting

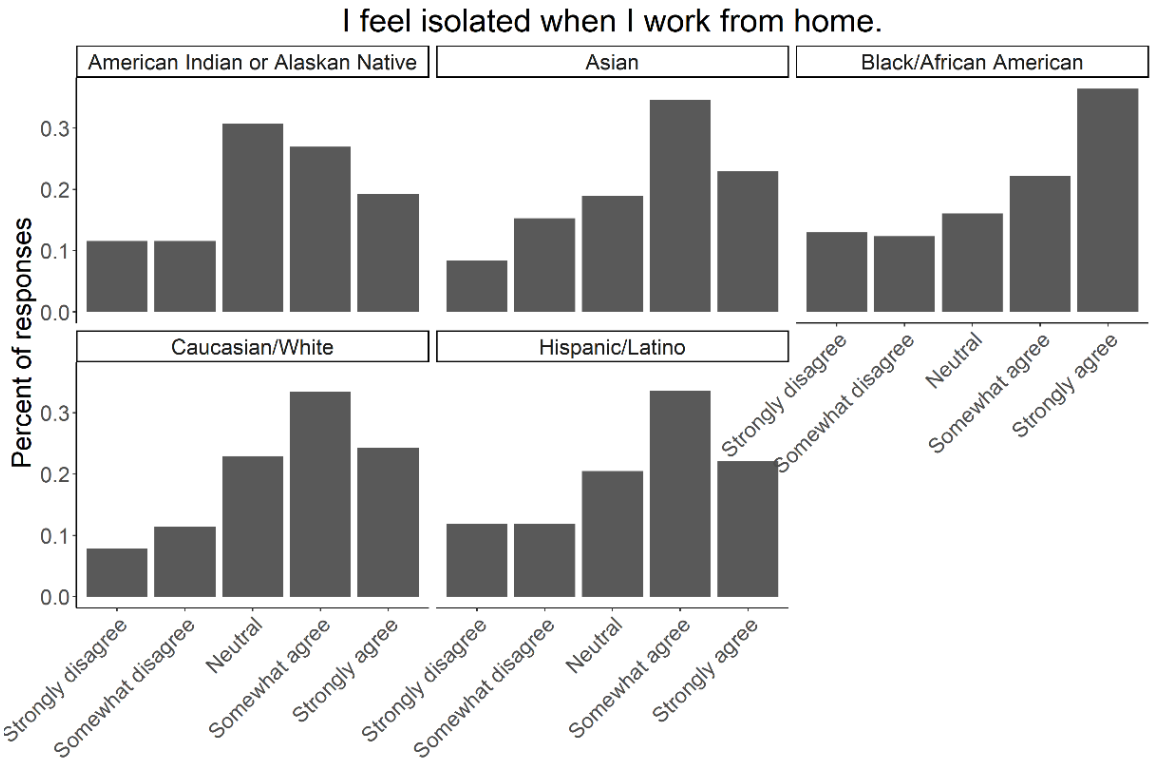
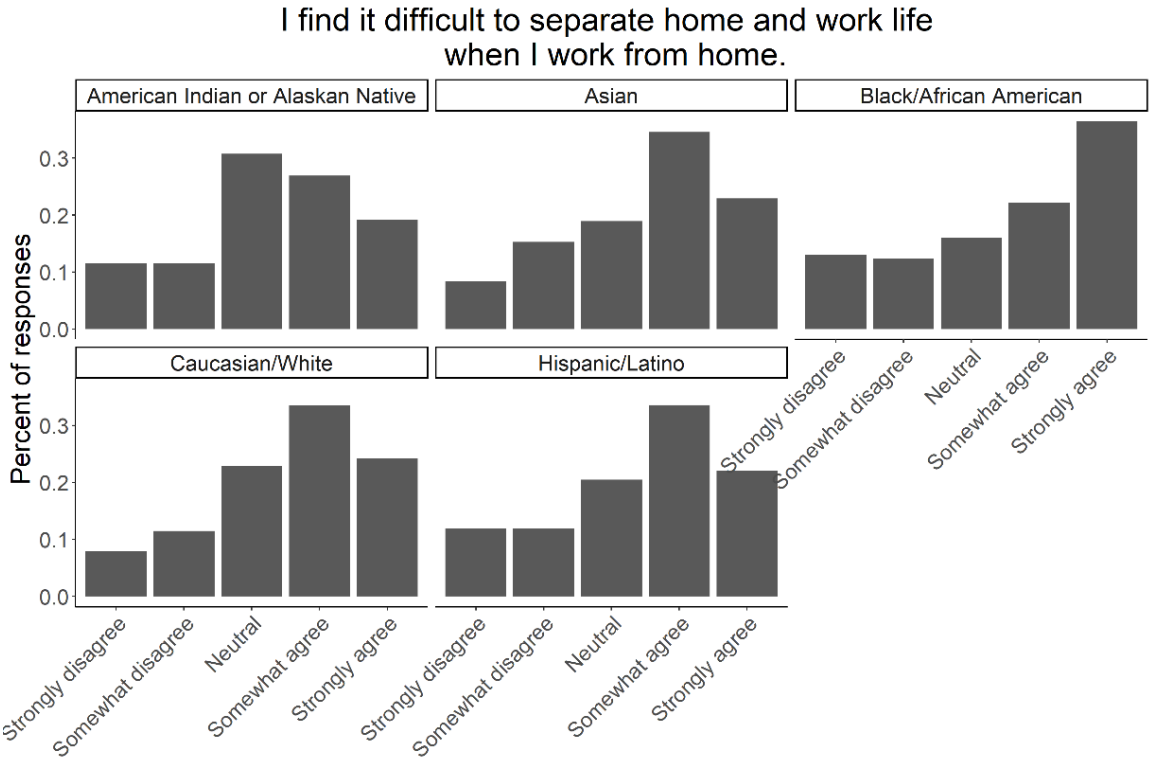


Figure 21. Survey Responses by Race: Separating Home and Work when Telecommuting



4.2.4 By Education

- Most respondents with Bachelor's/undergraduate or Master's ideally preferred working three days in the office, while respondents with high school education, a professional degree, or some college education preferred fully working from home over the next three years (Figure 22).

- Most respondents with a high school education, some college, or associated degree strongly disagreed that they have better equipment and internet access to work from home during COVID-19 as compared to the experience of working in the office before the pandemic (Figure 23).

Figure 22. Survey Responses by Education: Ideal Days of Commuting in Future

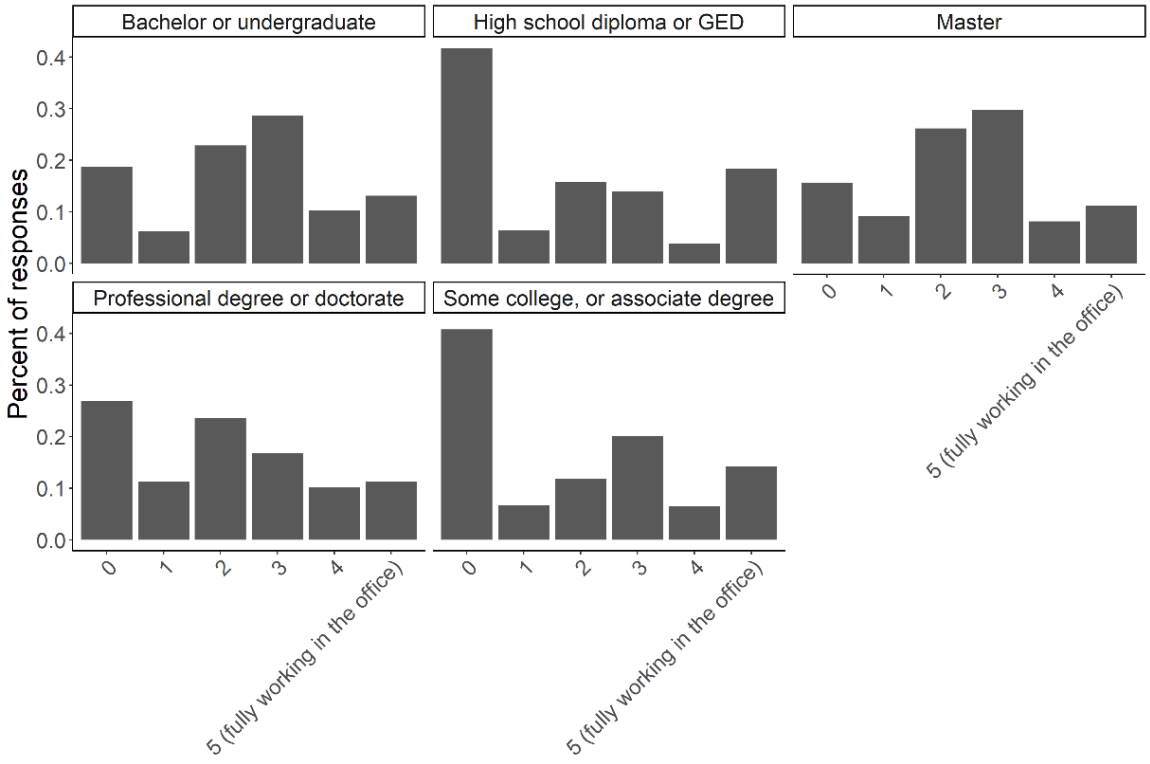
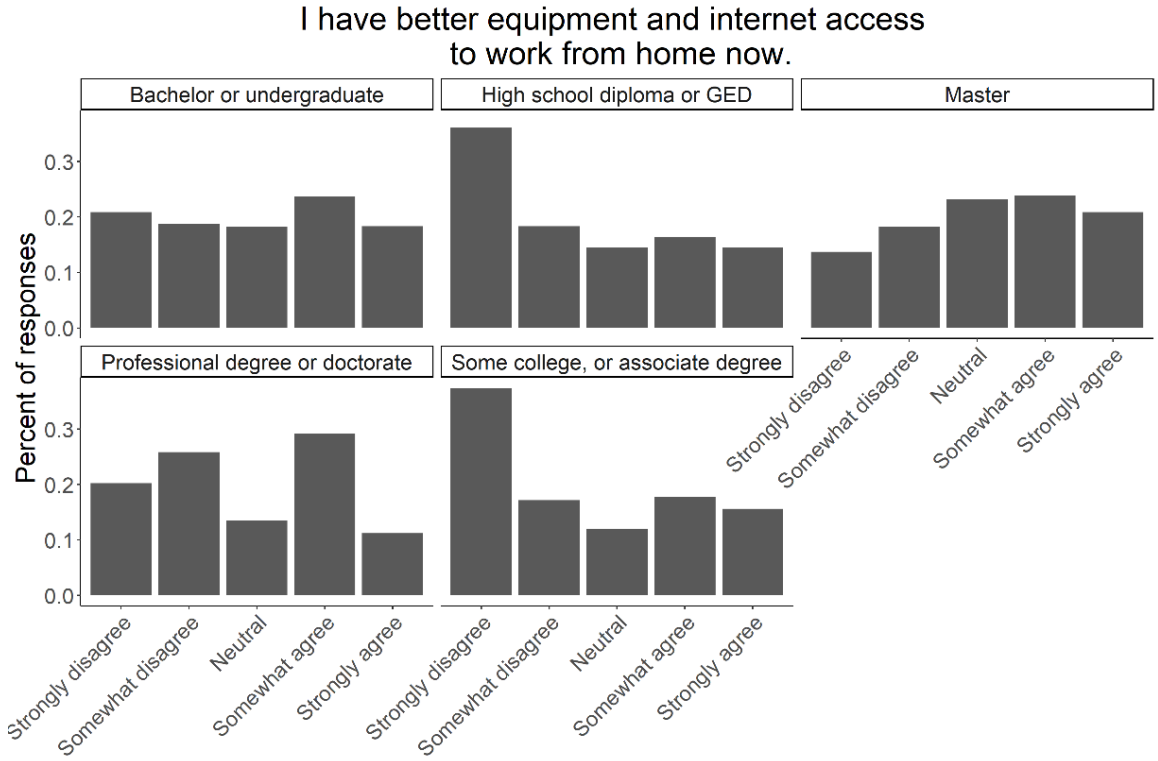


Figure 23. Survey Responses by Education: Equipment and Internet Access



4.2.5 By Household Income

- Most respondents with the lowest (< $25,000) and the highest (> $200,000) household income ideally preferred fully working from home, while respondents with household incomes of $25,000–$99,999 preferred working three days in the office over the next three years (Figure 24).

- Most respondents with household income below $74,999 strongly disagreed that their equipment and internet access to work from home during COVID-19 had improved since the beginning of the pandemic. (Figure 25).

Figure 24. Survey Responses by Income: Ideal Days of Commuting Over the Next Three Years

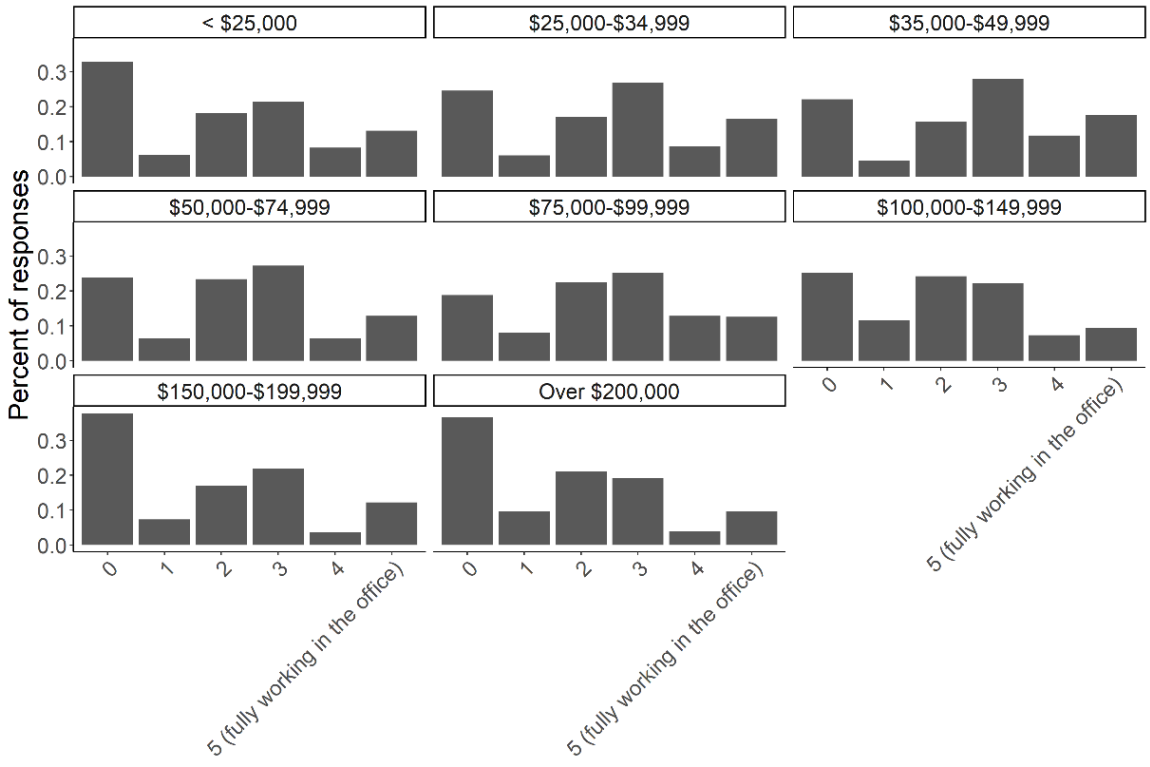
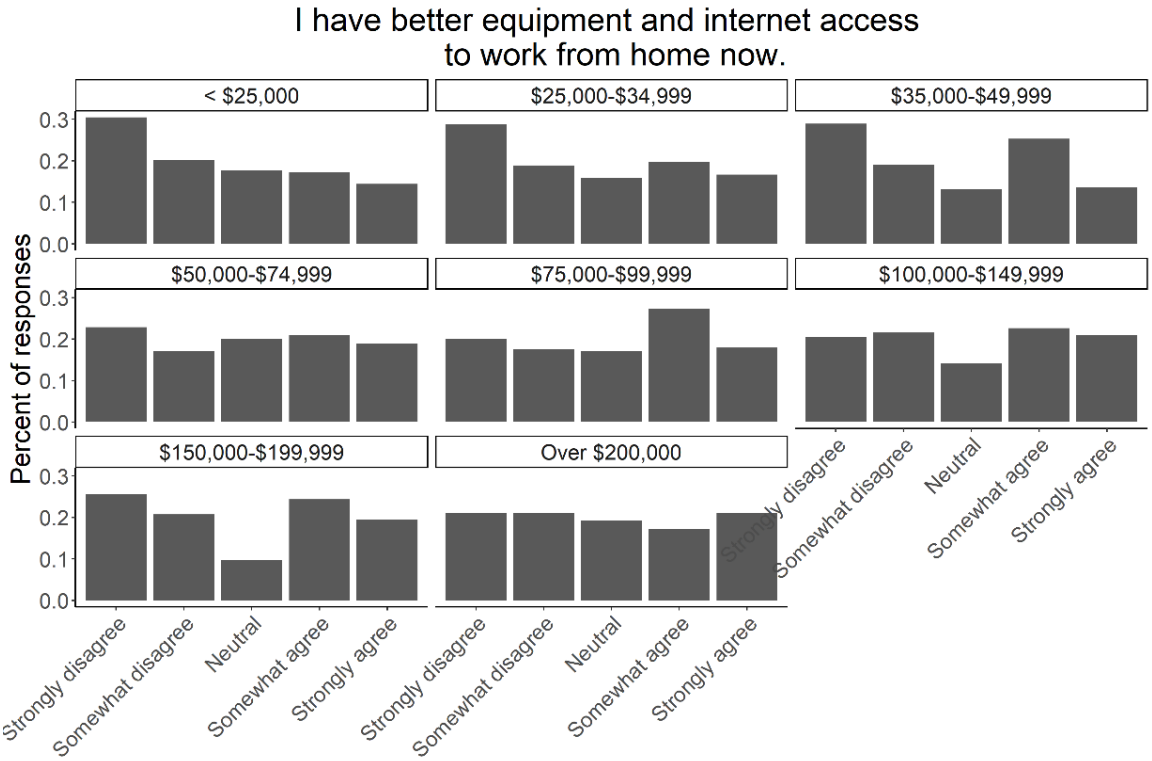


Figure 25. Survey Responses by Income: Equipment and Internet Access



4.2.6 By Work Status

- Full-time student respondents, part-time employed respondents, and respondents who are not working ideally preferred fully working from home over the next three years (Figure 26).
- Most part-time-employed, full-time-employed, and part-time-student respondents did not have improved equipment and internet access to work from home since the beginning of COVID-19 (Figure 27).
- Respondents who are employed full-time generally owned their home while other respondents were more likely to rent.

Figure 26. Survey Responses by Work Status: Ideal Days of Commuting Over the Next Three Years

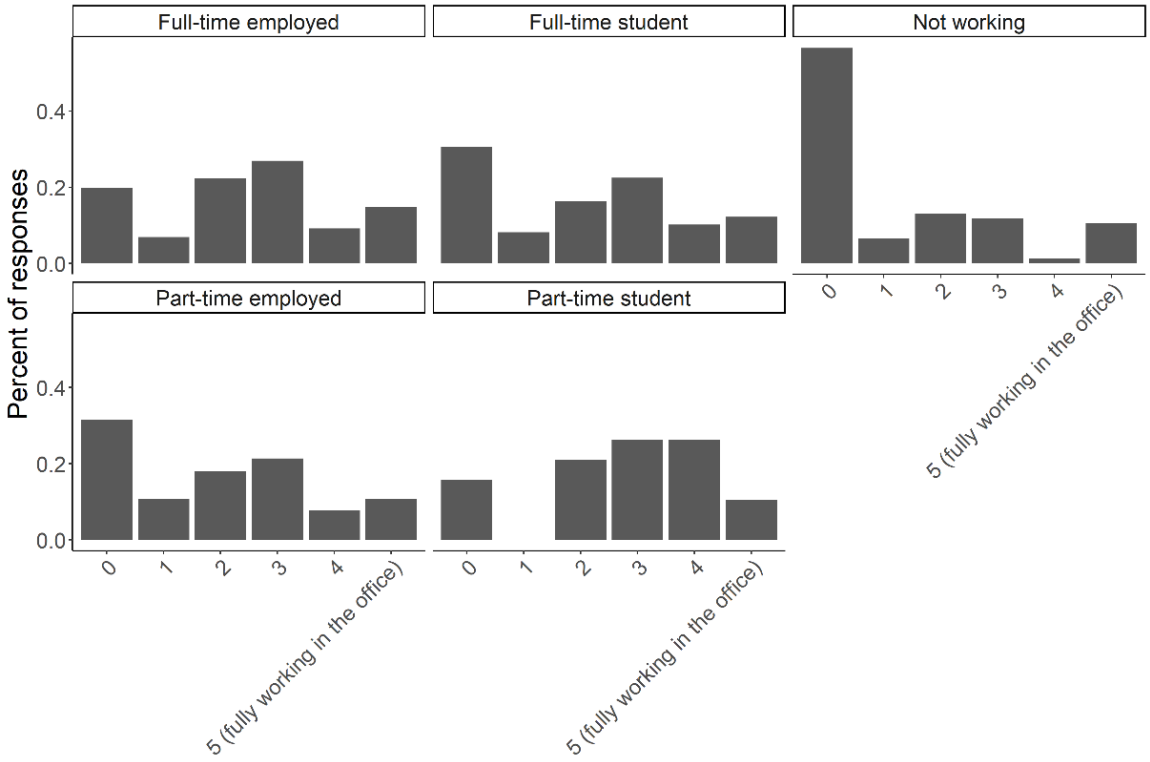
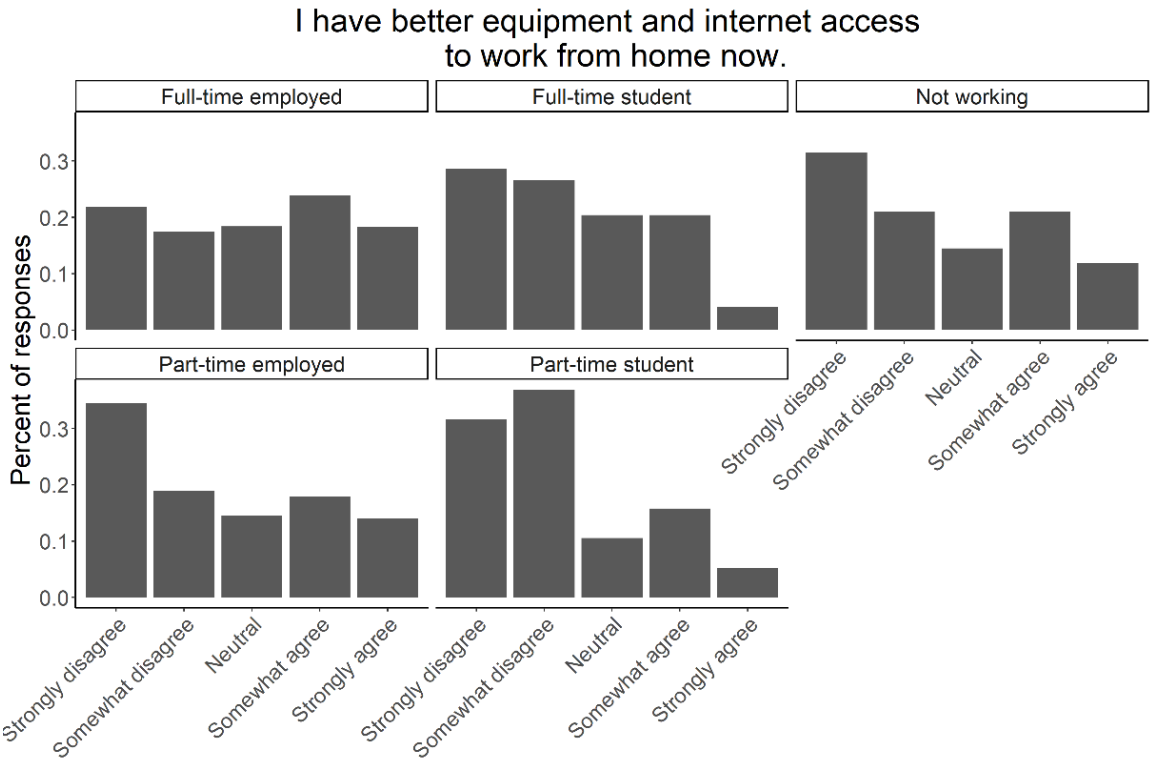


Figure 27. Survey Responses by Work Status: Equipment and Internet Access



4.2.7 By Marital Status

- Most married respondents ideally preferred working three days in the office, while single and divorced respondents preferred fully working from home over the next three years (Figure 28).
- Most single and divorced respondents did not work in a management position in contrast with most married respondents.
- Most single and divorced respondents did not have improved access to equipment and internet when working from home since the beginning of COVID-19 in contrast with most married respondents (Figure 29).
- Most single and divorced respondents rented their home, while married respondents generally owned their home.

Figure 28. Survey Responses by Marital Status: Ideal Days of Commuting Over the Next Three Years

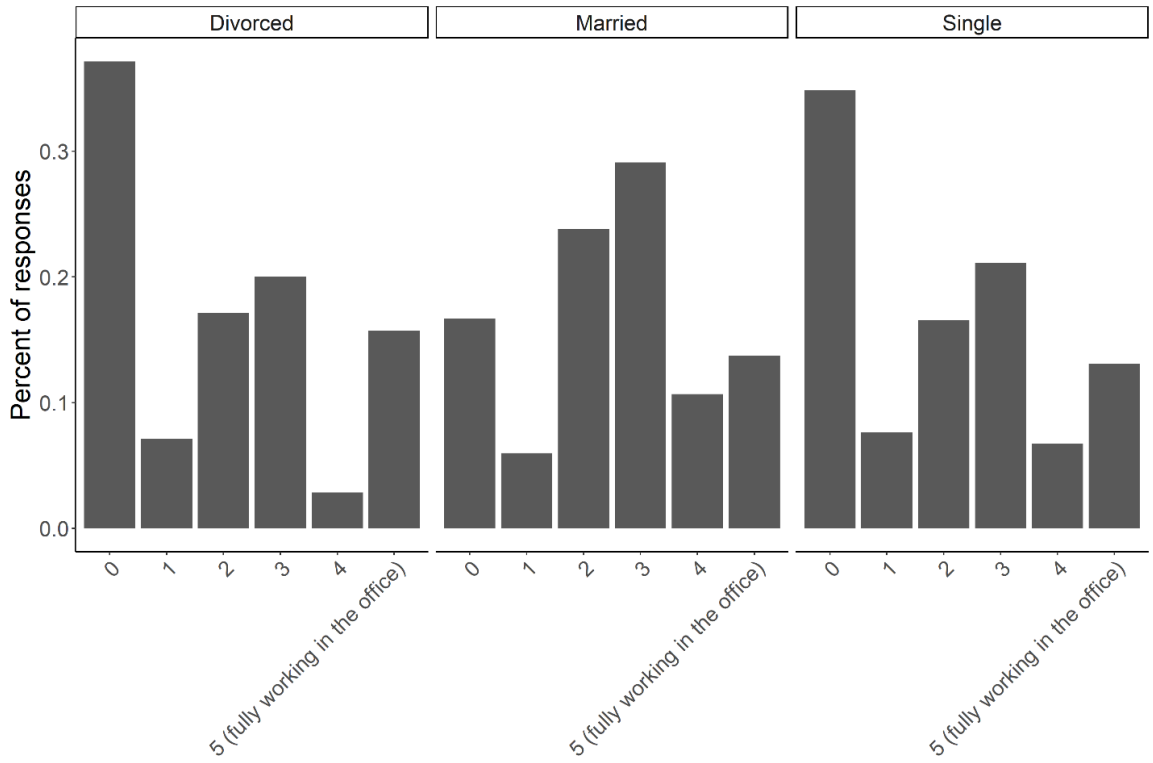
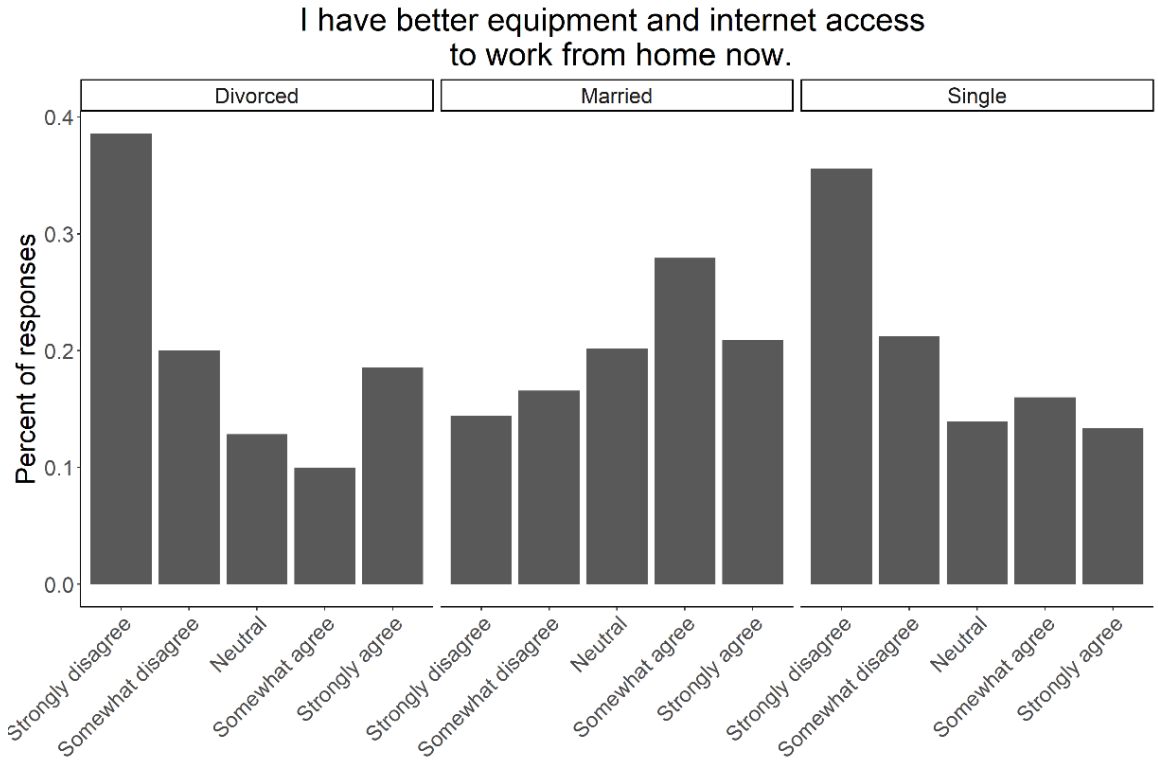


Figure 29. Survey Responses by Marital Status: Equipment and Internet Access



4.2.8 By Number of Children

- Most respondents with one or two children ideally preferred working three days in the office, while respondents with no children or three or more children preferred fully working from home over the next three years (Figure 30).

- Most respondents, regardless of number of children, somewhat agreed that they had more flexibility to choose their own schedule during COVID-19 and enjoyed improved performance since working from home; however, most of them somewhat felt isolated and found it difficult to separate home and work life when working from home (Figures 31–34).

Figure 30. Survey Responses by Number of Children: Ideal Days of Commuting Over the Next Three Years

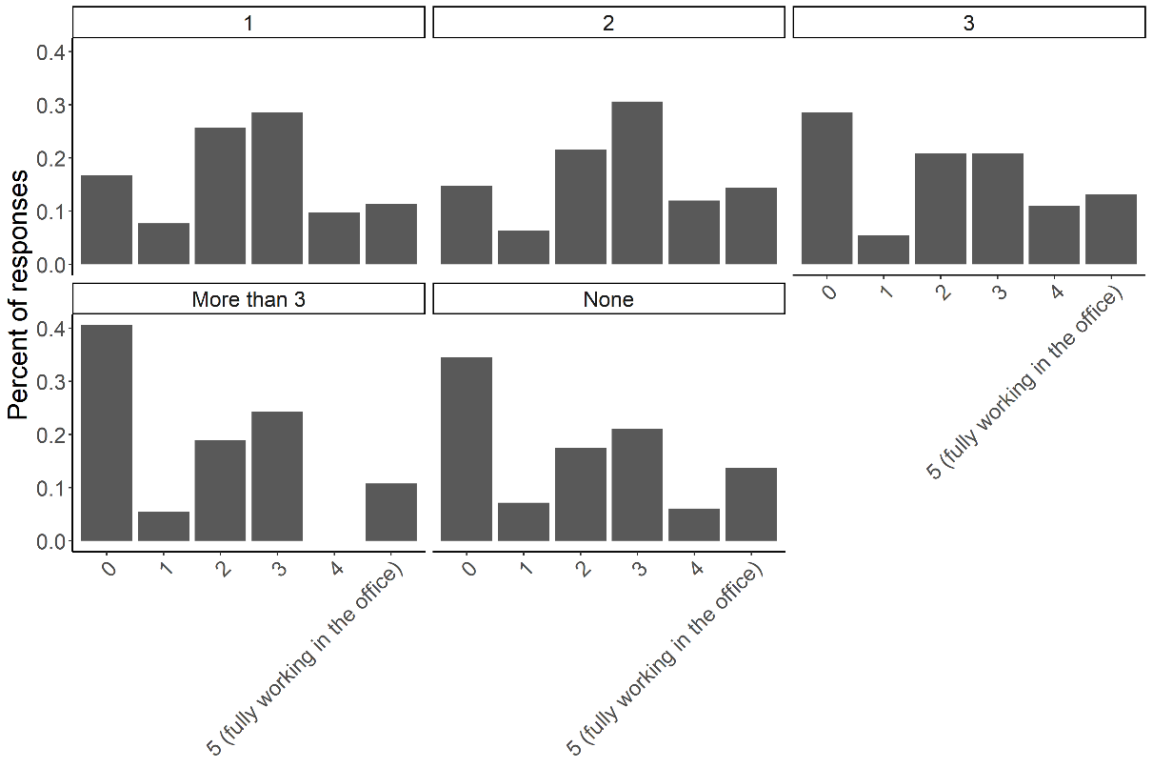


Figure 31. Survey Responses by Number of Children: Flexibility During COVID-19

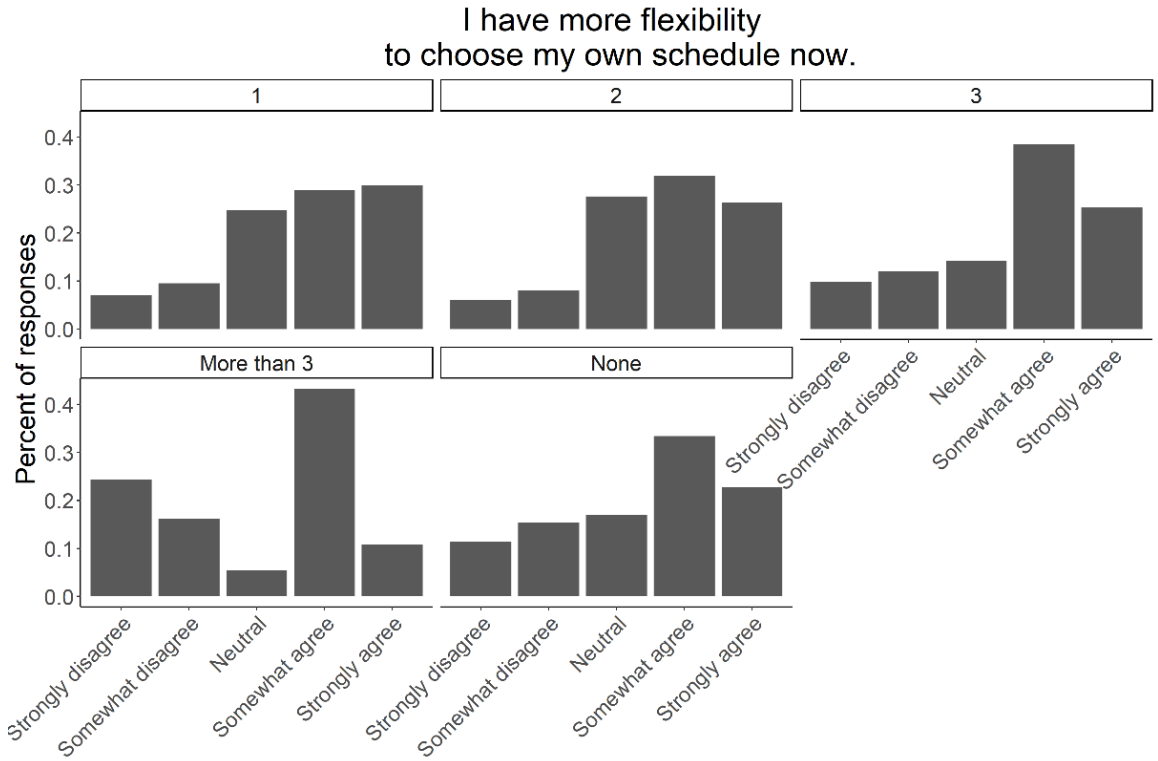


Figure 32. Survey Responses by Number of Children: Improved Working Performance when Telecommuting

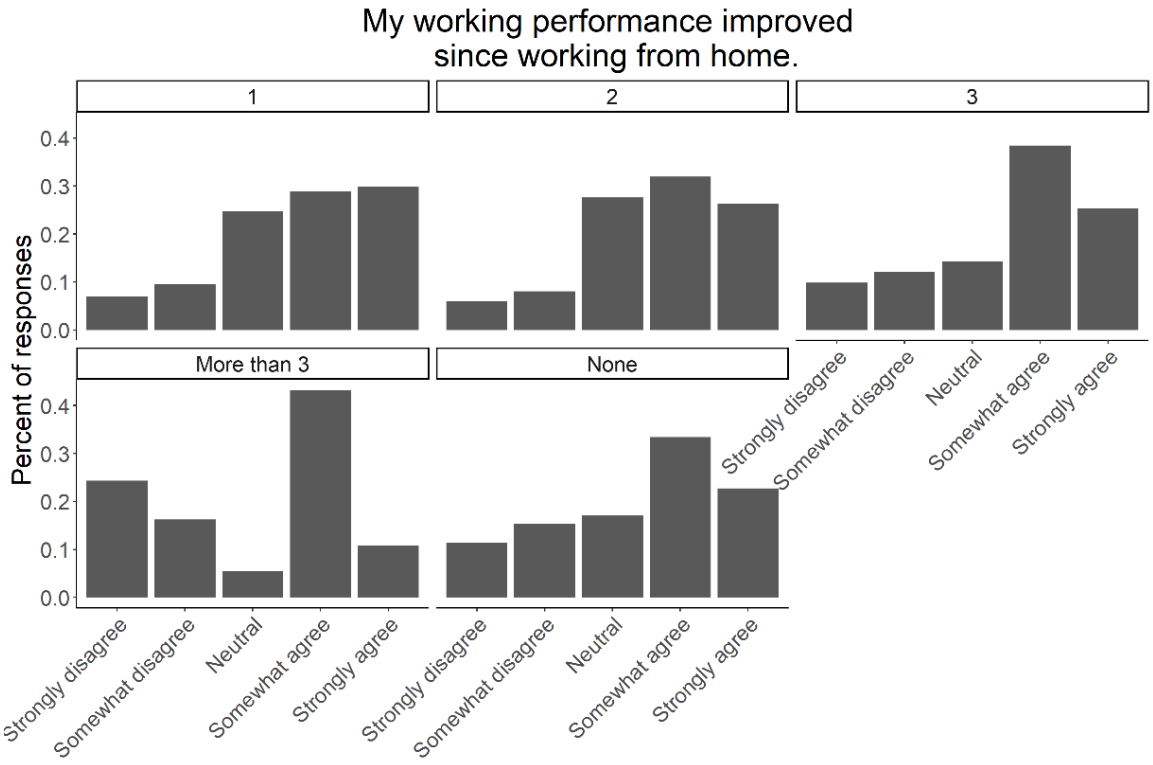


Figure 33. Survey Responses by Number of Children: Feeling Isolated when Telecommuting

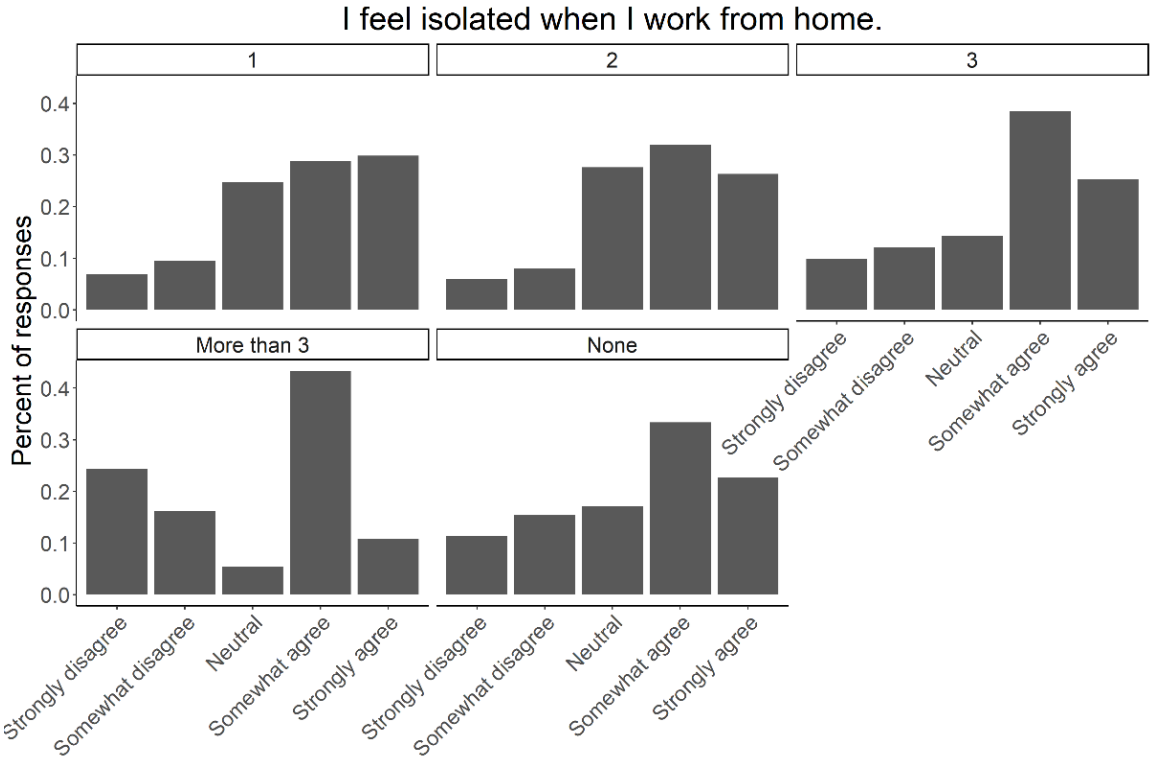
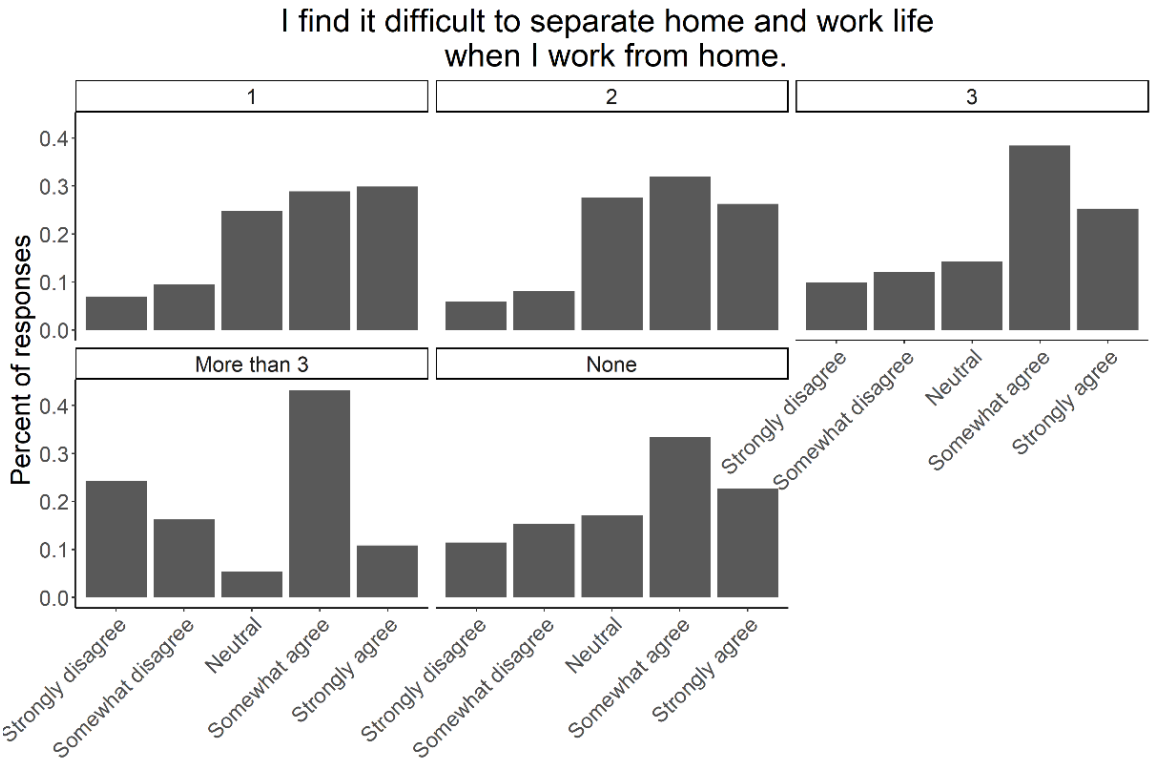


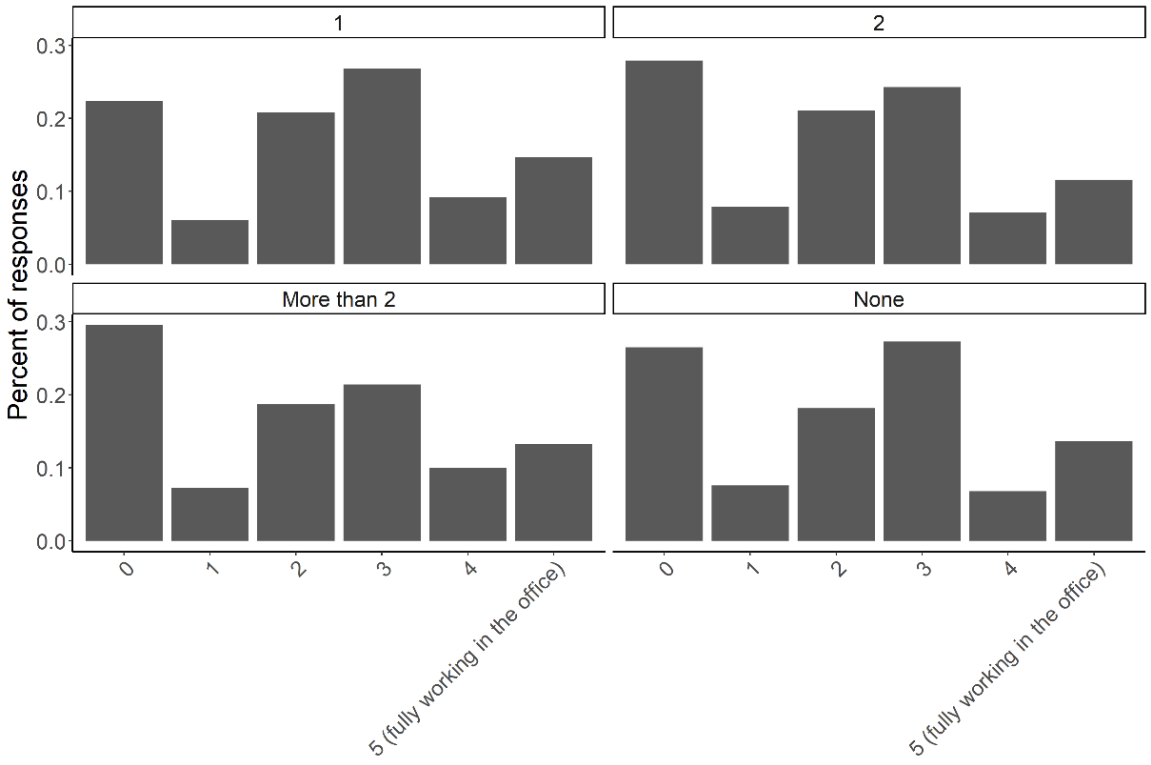
Figure 34. Survey Responses by Number of Children: Separating Home and Work when Telecommuting



4.2.9 By Number of Cars

- Respondents with one car in the household seemed to prefer working three days in the office. Respondents with two or more cars preferred fully working from home over the next three years (Figure 35).
- Most respondents with no car or one car in the household worked in the information industry.
- Most respondents with no car in the household rented their home, while respondents with two or more cars were more likely to own their home.

Figure 35. Survey Responses by Number of Cars: Ideal Days of Commuting Over the Next Three Years



4.2.10 By Overall Health

- Most of the respondents with fair and poor health preferred fully working from home, while respondents with excellent and very good health preferred working three days in the office over the next three years (Figure 36).
- Respondents reporting fair health did not work in a management position, while respondents with excellent and very good health were more likely to work in a management position.
- Most respondents with fair health did not have the privilege of getting better equipment and internet access to work from home during COVID-19 as compared to before-pandemic experience (Figure 37).
- Most of the respondents with fair and poor health rented their home, while respondents with excellent and very good health were more likely to own their home.

Figure 36. Survey Responses by Overall Health: Ideal Days of Commuting Over the Next Three Years

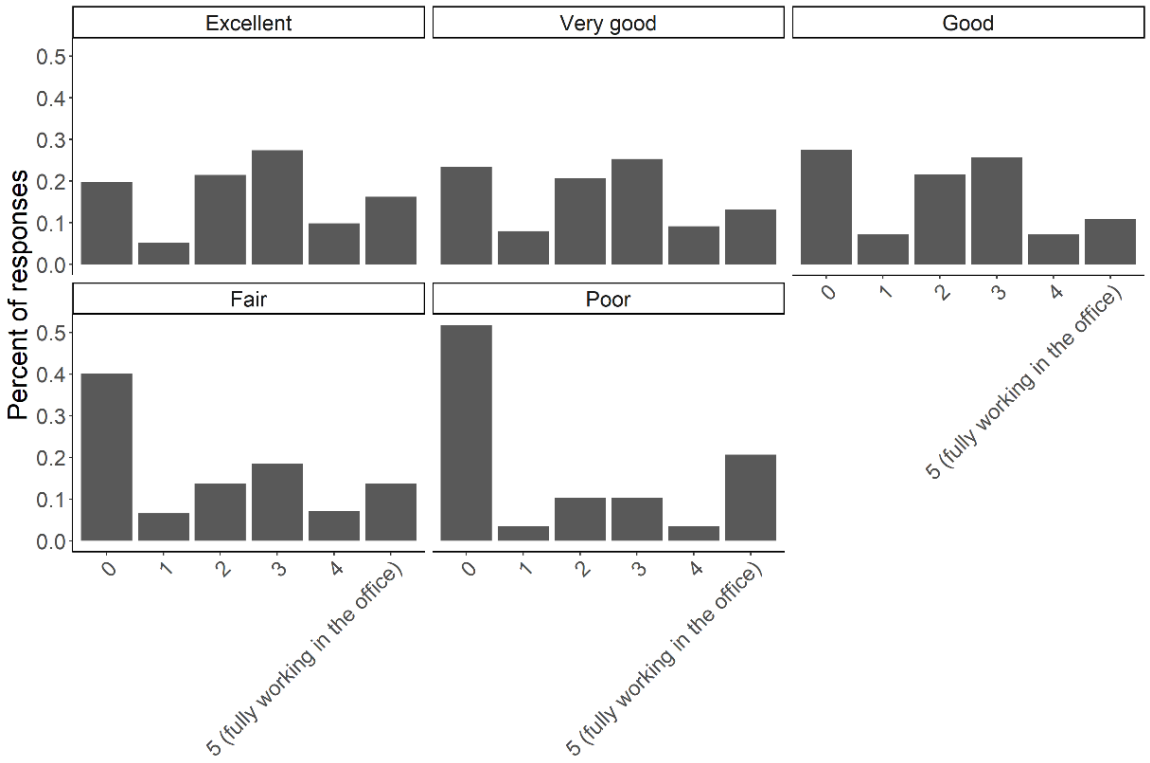
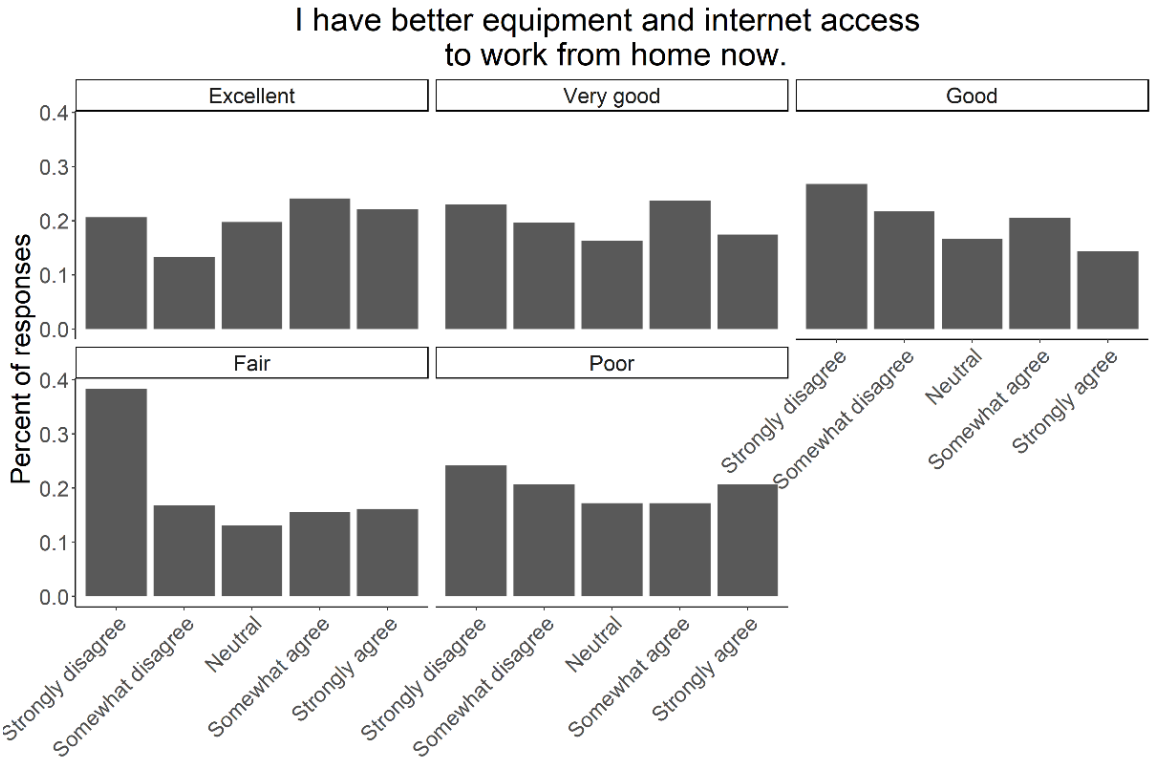


Figure 37. Survey Responses by Overall Health: Equipment and Internet Access



5. Findings from State-Level Interviews

Our state-level interview process was completed on February 16, 2022, resulting in 28 valid responses from industry experts. Below, we present the historical and current patterns as well as anticipated future trends of telecommuting based on the interview responses. Interviewees were senior staff, managers, or directors from the top ten industries in terms of employment in California.

5.1 Utility

- The interviewees are from Southern California Edison (SCE) and a water supply company.
- Before the pandemic, the office staff had the flexibility of telecommuting depending on cases and the managers' decisions.
- During COVID-19, all office employees (20–50% of all employees) work from home in both companies. The exception includes the employees in the field operations and printing department.
- SCE provides a laptop for each employee and reimburses for ergonomics equipment such as a table, chair, monitor, keyboard, and mouse.
- The increase in telecommuting will not affect hiring or the size of the workforce. The company policy is to have employees work and live within the state of California. It is unlikely the company would allow permanent remote working. The number of workforces in the regulated energy industry is determined by CPUC (California Public Utility Committee).
- The interviewee of the water supply company indicated that telecommuting is not expected after COVID-19. Management prefers to treat all employees (office and field operations) equally in terms of telecommuting.

5.2 Transportation and Warehouses

One interviewee is from a commercial real estate company which has branches throughout the U.S.

- In the commercial real estate company, employees shifted to 100% telecommuting or hybrid during COVID-19. Some employees in the Bay Area and Los Angeles moved to Phoenix and Houston due to the lower cost of living when telecommuting is possible.
- Productivity went up in the second year of the pandemic. There were technical difficulties and lower productivity when the employees started to work from home. The primary

reason is that many employees are not tech-savvy and needed time to learn how to work and communicate remotely.

Four interviewees work for the transportation department of the state or counties.

- There was no telecommuting policy prior to COVID-19.
- Administrative workers (planning, real estate, grants, etc.) could completely work from home at the beginning of COVID-19, while hands-on workers (mechanics, operators, some engineers) cannot. Starting from August 2021, people shifted to a hybrid mode, going back to the office 1-3 days a week.
- One interviewee works in San José and resides 100 miles away from the office. He has a strong preference for telecommuting. When telecommuting is possible, he has better meals, rest, and quality of life, and therefore his brain works better during work. Employees get more work done and work longer hours when working from home. He indicated that he would quit the job if the management wanted to bring everyone back to the office.
- The HR gave offers to three CFO candidates, but all offers were turned down because telecommuting is not an option.
- The organization was a victim of a cyber-attack and required deleting the VPN (Virtual Private Network) software that gave remote workers access to agency programs and files. The agency is working to reinitiate a VPN server and has modified access to the key programs to serve remote worker accesses.
- Some interviewees mentioned that the organization owns the building and has no plan to rent out or reduce the workspace. Some interviewees noted that the new district building lease/construction/rehabilitation has been put on hold, and some districts have consolidated buildings during the telework phase.
- Everyone needs to be fully vaccinated before they go back to the workplace. One interviewee indicates that the organization offers an incentive for being vaccinated (each shot = 8-hour time off).
- When telecommuting is possible, the applicant pool has expanded. People that live further are now willing to apply for limited-term positions due to the current emergency telework program. The situation has not changed for permanent positions due to the uncertainty of telework after the emergency is lifted.
- Several interviewees expected management to continue support for telework (full time & part-time) and flexible schedules for all positions after COVID-19.

5.3 Retail and Wholesale

The interviewee works for the retailer which owns a chain of a membership-only warehouse club and is listed among the top five largest retailers in the world.

- Before the pandemic, there was no work-from-home option. During the pandemic, hourly corporate and regional employees in merchandising, traffic, and inventory control departments could work from home 3 days a week. First-line managers are allowed to work from home one day a week except for Monday. Monday is the day for the meeting of weekly sales comparison, and all managers need to meet on that day. Front-line employees are not allowed to telecommute.

- They lost some talent because other companies offer a similar salary with a full work-from-home option. To keep talent, this company increases pay for some positions. They believe that they could have kept more talent if telecommuting were a bigger part of the work program.

- Training new employees is challenging in an online setting. New employees need to learn abundant information in the buying department. The buying sub-culture will not be learned until the employees spend time in the department at work. All employees need to work at the front line first and get promoted to the positions in which they can work in the office and telecommuting becomes an option.

- This company will not have any change in real estate strategy after telecommuting is allowed. All offices are located on top of retail sites which are fully owned by the company.

5.4 Education Services

One interviewee works for a community college.

- Before the pandemic, there were no telework practices. During COVID-19, classified staff occasionally went back (e.g., distributing materials to students), then back full time in August 2021. Now all staff are working on site. The college offered a remote pilot, but the plan is not feasible, as staff need to have their own office space. Faculty can decide to teach remotely or on-campus.

- All community college members should complete Cleared4 access to be able to enter/attend any of the facilities/classes. Cleared4 consists of a profile, a COVID-19 test appointment, and daily questionnaires.

- In January and February of 2022, the college would have all classes online, but offices would remain open during regular business.

- They are currently seeking new student workers who would work on-site only, but they are also teaching them how to work remotely.

Another interviewee works for the University of California (UC) Office.

- Prior to the pandemic, there was some flexibility to allow employees to work from home as necessary. During COVID-19, most employees are flexible workers, and only essential staff like IT are required to conduct on-site work.

- Staff are more productive working from home. Staff satisfaction and morale have improved with the introduction of remote work. Training is more difficult in an online setting.

- UC is currently in the process of finalizing the "Future of Work" policy. If approved for hybrid or remote work, staff will be asked to complete telecommuting agreements.

- Before the pandemic, they entered a partnership to build a new office building to bring everyone into the same building. The pandemic caused a revision to the plan. Since so much of the workforce will be remote, extra space will be leased. In the long run, office space will be reduced, and "hoteling" or "hot-desking" will be undertaken. Hoteling is the system that employees can dynamically schedule their use of workspaces. Hot-desking is an organizational workspace system in which desks are used by different people at different times, on an ad hoc basis

- Some UC campuses have already hired staff located outside of California. With respect to hires outside of California, UC is already working on tax guidance for those employees. There are tax implications about moving out of state—if you work in another state, you need to report to both states. There are difficult "optics" for paid UC workers who live out of state.

- Now that remote work is available, some workers have moved out of state to be closer to family. Most who have moved have moved in-state to more rural or ex-urban areas.

5.5 Health Care and Social Assistance

One interviewee is from healthcare administration (specifically, a hospital system comprising 3 hospitals, 2 skilled nursing facilities, and 7 clinics).

- The pre-pandemic telecommuting policy did not allow for telecommuting except in extenuating circumstances. The leadership is currently in the process of developing a new/updated telecommuting policy.

- They have about 5,100 staff, of whom 3,500 are "essential workers" who are front-facing clinical staff and do not have any flexibility to work from home. Of the remaining staff,

about 2,000 (39%) are in positions that are allowed fully remote or a hybrid remote work schedule pending the supervisor's approval and the completion of a telecommuting agreement. They belong to IT (only coding/application maintenance IT staff), finance, purchasing, payroll, human resources, legal, contracting, regulatory compliance, and medical staff services.

- There has been no decrease in productivity and staff morale has been good.

- They are actively evaluating the real estate portfolio to determine what roles can be fully remote and what roles will require permanent office spaces. Hybrid roles will be provided "hotel" seating. They were in the process of acquiring a new space to accommodate growth, but this deal was canceled. They are actively completing surveys that will inform the remote work policy and identify roles that can be converted to full remote status. Office space will be reduced.

- The learning/education department has converted all leadership training to zoom training. This had expanded their ability to enroll more staff than when these were held in person.

- Human resources is actively working on adding modules to allow for additional out-of-state capabilities.

Another interviewee works for the Department of Public Health Division of LA County.

- Before COVID-19, employees could choose from various flexible schedules. Each department determines which jobs are essential and which are non-essential. During COVID-19, all non-essential county employees (80%) were placed in telework status during the Safer at Home and Stay at Home orders given by LA officials and the Governor. The date of returning to the office was pushed back three times due to the COVID-19 variants.

- For training that included external partners, they found an increase in overall participation. Because of traffic in LA, the biggest challenge when scheduling meetings with external partners was that no one wanted to drive into Los Angeles. Going virtual helped with this problem.

- Productivity increases noticeably. The director implemented daily check-ins (morning: what tasks will be done that day) and check-outs (evening: what was done) and kept all staff on track for meeting deliverables. The state congratulated the department for surpassing the deliverables during this time.

- Technology was the biggest challenge in the first couple of months of the pandemic. Some of the more experienced staff were Zoom-illiterate, and it took them a while to figure out

how to get connected, use their camera and microphone, etc. Also, not everyone had the proper hardware (computer, laptop, software) to telework.

- Staff with children and spouses also working from home discussed having too many distractions. This was also the case in the beginning of the pandemic when everyone was still adjusting to their new working environment. The director allowed those who had too many distractions to go into the office to work if the number of people in the office did not exceed a certain number and masks and distance were maintained.

- The county is offering "hoteling" at various county facilities for staff to work from. Consolidating office locations has been in the works for the past couple of months.

- Full-time teleworking will not be permanent for most staff because they deal a lot with the community and work out in the field. However, positions that solely focus on data analysis and evaluation where they do not have to go out into the field have the potential to telework solely.

5.6 Professional and Business Services (Software, Construction Materials Delivery)

One interviewee is the CEO of a company that provides software and hardware services to cities and counties.

- Given the company's nature, most employees had been telecommuting before COVID-19. Some employees are in India and other countries. During and after COVID-19, all U.S. and overseas employees work from home.

- The company plans to reduce 50% of the headquarter space due to the shift to full telecommuting mode.

- Productivity went up during COVID-19. The challenges include more meetings than before, employees with kids at home, changes in management style, and daily check-ins required.

- Because telecommuting is allowed, the company can save costs by recruiting employees from the cities/countries with lower living costs and paying them lower salaries.

- The company plans to hire more people in the future because telecommuting lowers the costs.

Another interviewee is from a company which delivers construction materials.

- Before COVID-19, it was a hybrid setup. During COVID-19, all people can fully remote work while some choose to work in person at the headquarters.

- Virtual training is more challenging because of lacks in two-way interaction. Collaboration is difficult because you cannot have multiple conversations at once.

- Problem-solving can be difficult. It can be challenging to have conversations over Slack when it takes place outside of a meeting. You may misread someone's tone (which can cause negative feelings), you can come across the wrong way, or it can just get confusing with multiple people chiming in. Extra tooling such as Discord or Google Meet can make the problem-solving process significantly easier.

- The cost savings of having a remote workforce are huge, which means more workers can be hired if needed. The overall pool of job applicants is larger since you do not need to focus on a specific geographic area to acquire talents. This provides more opportunities to find top talent.

5.7 Federal, State, and Local Government

Five interviewees work for federal, state, or county governments.

- The interviewee works for the US Government Federal Tax Administration/IRS.

- IRS (Internal Revenue Service) offered Flexible Work Schedule (FWS) and Compressed Work Schedule (CWS) before COVID-19 and mandated telework status for all eligible employees during the pandemic. An expanded "Maxiflex" work schedule can adjust start and stop times, expand unpaid mealtimes, and expand or reduce work hours to address caregiving necessities with managerial approval.

- As the IRS operations are subject to congressional budget plans and approval, the expectation for changes in work locations and type could not be determined at the time of data collection.

- The IRS has recently increased its efforts to enhance taxpayer access to IRS personnel through enhanced camera use during virtual media contacts. This improvement is expected to strengthen taxpayer confidence in communicating with authorized IRS personnel and taxpayer data security.

- The IRS has employed a new comprehensive planning structure under the title "IRS Next" that is currently focusing on delivering on the Training Strategy of the Taxpayer First Act (of 2019) by improving current processes and practices via adaptation to the latest communication media to best assist and administer a host of federal tax-related matters. A strategic blend of face-to-face and virtual interactions will be part of this new make-up.

- IRS expects to expand its workforce in the future. Telecommuting will be an integral part of the IRS' execution of effective federal tax administration in the future. Employee work-

life balance proves essential to ensuring that quality personnel is positioned to provide top-quality service to taxpayers to learn and meet federal tax obligations. Strategic telecommuting practices will aid the IRS in attracting, training, and retaining a comprehensive work team to deliver top-quality service to the American public.

Four interviewees work for California state or county governments.

- Before COVID-19, some organizations such as the Southern California Association of Governments (SCAG) were already in the process of having all staff telecommute once or twice a week due to office space limitations, and the pandemic has greatly accelerated that process. During the pandemic, 80-100% of employees work remotely.

- The interviewees reported higher productivity when working at home and a better life-work balance. Some organizations had success doing remote training and converted most processes to digital.

- While short-term productivity improved, some interviewees had concerns about long-term productivity. Some work is collaborative, and unstructured discussions and collaboration are hard to achieve online, especially at the initial stages of projects—dividing up work, managing tasks, establishing connections, and collaborative approaches.

- During COVID-19 and the telecommuting mode, there were decreased unexcused absences and sick leaves. Employees could schedule an appointment before their start time, after work hours, and during lunch hours. This extra time is normally used for driving to and from work pre- and post-COVID.

- Working from home may challenge new employees who need to learn the culture and staff.

- As for future trends, some interviewees predicted that telecommuting would continue, and the days of the five-day work week in the office are gone. Because most work does not require a physical presence in an office, one interviewee foresees hiring more people to work remotely from other countries or states and existing employees moving to other parts of the state or country soon.

- If the office is attended, it will require a vaccination mandate.

- Over the next 12 months, some organizations will invest in more tools for virtual collaboration. They have already upgraded conference rooms for hybrid meetings and added software and hardware for communal space check-outs.

- One interviewee indicated that the staff is not computer-savvy about the training for using virtual tools. Management will need to provide in-person, hands-on training to teach staff how to use virtual tools and electronic services. Technologically inept managers will need

to attend classes or enroll in online courses for instructions.

- Prospective applicants are asking about the possibility of telecommuting before they even apply, and it comes up in every interview. The legal and logistical challenges of employees outside the state of California are a deterrent. However, a California law prohibits the public agency from requiring residence in the jurisdiction.

5.8 Finance and Insurance

One interviewee works for the finance team of a high-tech company.

- Before COVID-19, the arrangement was more hybrid-like as people were expected to come into the office regularly. During the pandemic, the whole company is in telecommuting mode. The interviewee does not expect the flexible work arrangement to change in 12 months.

- Because of the telecommuting model, the company hires people from other states and even other countries.

- The interviewee expects that the size of the workforce will decrease, mainly because most work done remotely is specialized in nature, and wide distribution of the workforce tends to lead to a reduction in shared services staff.

Another interview works for an insurance company.

- The trend toward flexibility and remote work was already underway before the pandemic, with approximately 25% of employees working full-time as remote workers. However, with the advent of the pandemic, all non-essential workers began working remotely, accelerating the trend toward more flexible working practices. The company has been moving in that direction for the past several years.

- They learned that many employees prefer to work remotely with greater flexibility. Employees have told the company in surveys that they would prefer more flexibility. It makes them more productive, reduces commuting time, and improves their overall wellbeing, all of which contribute to their enhanced engagement at work. As a result, flexible work will remain an essential part of how they operate post-pandemic.

- Before the pandemic, the company had already invested heavily in online learning platforms, allowing them to deliver content and facilitate learning remotely. They found virtual delivery of training-based content to be both effective and efficient, often allowing the intended learner to consume content at their own pace and as best fits their schedule. Further, when instructor-led training is necessary, virtual learning promotes the building

of larger cohorts, promoting engagement and efficient content delivery from training personnel.

- They began reducing their real estate footprint. Offices with expiring leases did not renew, and offices with termination rights terminated their leases. Moving forward, the interviewee anticipates that they will continue to minimize the real estate footprint to meet the evolving needs and capabilities of the company.

- The company will invest in remote technology, including

- Tools for virtual collaboration.

- IT infrastructure to secure virtual connectivity.

- Training for managers to manage a more virtual workforce.

- Conference rooms with enhanced virtual connectivity.

- Hoteling applications.

- Communal space in the office.

- Unassigned (or hoteling) seating in the office.

- To design workforce development programs that train managers and workers for success when using flexible work practices, the interviewee emphasized the need to maintain strong company culture by enhancing interpersonal relationships and trust and building connections among people virtually. In addition, employees face different challenges now that most work is being done at home, where distractions abound. It will be essential to help employees develop a schedule that maximizes their productivity and engagement while also helping them to create time management and prioritization skills that maximize their effectiveness while working.

- They have already begun posting more positions virtually and promoting employees from diverse geographical locales to apply.

5.9 Entertainment and Recreation

One interviewer works for a music company.

- 20% of employees work from home, and 80% who cannot telework belong to the production departments who travel a lot.

- The interviewee reported higher productivity because of better time management for the

team he manages and fewer distractions. However, the interviewee had difficulties training new hires or interns when remote.

- They are opening more satellite locations and will invest in tools for virtual collaboration.
- The company is hiring more people because of business growth and COVID-19. The executives are committed to maintaining in-person work environments as much as possible.

Another interviewee works for a company which holds live events at stadiums.

- Before the pandemic, people were expected to be in the office for 5 days per week plus any events assigned to on weekends. During the pandemic, people have the option to work from home 2–3 days a week to limit the amount of people in the office at any given time.
- Working remotely has worked out fine. They use different Microsoft products that allow them to communicate via instant messaging. The only exception is when a walk-through of the stadium with a client is required. In the first month of working from home, productivity went down a little bit because people started to get adapted to the remote mode. After that, productivity went up obviously. All work can be done on time. Most work is cloud-based, so working from home is no different from working at an office.
- Another interviewee fully expects to be required to the office full-time during the "post-pandemic" world. However, if an employee can prove that productivity does not decrease when working from home, there is no reason that the company does not allow working from home for some days after the pandemic.
- They run a stadium with live events so workers need to be available in-person when necessary. Some people got furlough during the pandemic. The company started to hire recently and offers telecommuting as an option.

One interviewee works for the tourism industry.

- Prior to the pandemic, the organization offered several schedules. The organization had four team members telecommuting and did not allow any other team members to telecommute.
- The current telecommuting policy is a direct result of the pandemic. All team members telecommute and primarily work from home. The organization has a physical office. Team members reserve a workspace by using an app when they need to be in the office. All team members must meet with their direct supervisor in person at least once a month. Each department must meet once a month in person. The entire organization meets in person once a quarter. The organization has been flexible to allow team members to work outside of their set schedule to make up hours missed due to sickness.

- One of the biggest challenges moving to a remote workplace is accessibility to employees. Getting a group of people together can be challenging. The team spent more time communicating, collaborating, breaking down siloes, and making sure everyone understands their role. Project management software such as Wrike, Monday.com, and Miro board are hugely helpful.

- The team leaders, not just people who check project to-do boxes, need to find ways to connect team members outside of work to help them grow closer to each other.

- The organization consolidated office space about 12 months ago. They reduced their footprint 50% and moved to the new remote/hybrid work environment. In the future, it is expected to move from a 1–2-day minimum per month to a 1-day weekly minimum in the office.

- Currently, staff members need to work in the state to be a part of the organization. The organization would not hire team members and have them work in other states. It is important for the employees to live in the region they are promoting and driving tourism to, so they understand the destination and partners.

- Telecommuting is a great selling tool for the organization. They are attracting talented individuals, and this is a selling point for them.

5.10 Manufacturing

One interviewee works for one of the largest global manufacturers of optoelectronic devices.

- Before COVID-19, there was no policy about telecommuting. After COVID-19, the telecommuting policies are different for corporate offices and the manufacturing facility.

- Corporate offices: Primarily professional positions, which allow for the opportunity for employees to work remotely. 90% work from home five days a week. 10%, not flexible workers are IT, Finance, and Legal team.

- Manufacturing facility: Primarily production roles which did not allow for employees to work remotely. Some engineering positions were given the flexibility to work a couple of days a week from home. Since these roles support manufacturing operations, it was challenging for those to be 100% remote: 3% work from home. Only salespeople can work from home.

- About the challenges, the company culture has shifted significantly due to remote work. There is less face-to-face interaction, which impacts relationships. There was also a significant challenge between employees juggling home responsibilities (children, spouse, etc.) and those who did not have the same duties. Because all social events have been

canceled, there is little interaction and translation among people. People do not turn on the camera during the meeting, so the presenter is talking to space.

- The company is currently assessing the telecommuting policy for the future, but there is a push at the organization to bring employees back to the workplace. The interviewee anticipates that they will see more flexibility for employees to occasionally work from home, but not a continuation for them to work remotely 100% of the time.

- About the government COVID-19 mandate, the mask is required in the house; people need to practice social distancing. Vaccination is required. Currently, 85% of employees are fully vaccinated, while 5% are exempted due to medical/religious reasons. They need to decide whether to terminate the 10% who are not vaccinated.

- The pandemic has opened the door for a wider network outside California. The company may hire more people from other states because of lower labor costs. Some directors/staff moved to Idaho, Florida, and Texas and will not come back to California.

Another interviewee works for a medical equipment manufacturer, whose activities are related to COVID-19.

- All employees are considered essential workers and are not allowed telecommuting. There are no flexible working practices before, during, or after COVID-19.

- The company hires more people and pays more for overtime because of solid demand.

- Inside the company, they practice social distancing and weekly testing. There is a mask mandate. They stopped all social events. They decreased the number of people in the conference room in meetings. A lot of those meetings were pushed to Zoom even though nobody worked from home. They would use Zoom from their desk inside the company. They also did not have any customers visit. Vaccination is not required for employees.

From the 28 interviews with the senior staff and managers in the ten industries, we summarize the major findings. Before the pandemic, several companies had no official telecommuting policy, while some companies had already started flexible and remote work. During the pandemic, most office staff were shifted to full or hybrid telecommuting, while essential or filed operations remained in person. Several interviewees experienced higher productivity levels when telecommuting, except during the transition period. Several interviewees, especially in high-cost areas, indicated a strong preference to stay in the telecommuting mode due to lower commuting costs and better quality of life. Some interviewees' colleagues have moved to other states and did not plan to move back to California. Several interviewees indicated that telecommuting enhances the quantity and quality of the talent pool and reduces the costs of hiring and employment. Some employers have stopped expanding, reducing, or rearranging their office space during COVID-19. Others have consolidated office locations and adopted hoteling/hotdesking.

For the future, some interviewees emphasized maintaining strong company culture by enhancing interpersonal relationships and trust as well as building connections among people virtually. It is essential to develop time management and prioritization skills that maximize employees' effectiveness in response to distractions at home. In addition, the companies which reduced, consolidated, or rearranged workspaces plan to continue with those measures. Some companies have lost employees to other companies which offered a similar salary with a full work-from-home option, and they plan to match this option to retain and even attract more talent.

6. Findings from the Regression Analyses

The COVID-19 pandemic presented a significant and sudden structural change in travel behavior. Using the best available data (as presented in Section 3.3), our regression analyses explore two broad levels of inquiry: first, whether pre-pandemic county-level factors appear to have influenced Californians' travel behavior at important moments during the pandemic, and second, whether dynamic county-level factors appear to have influenced monthly travel behavior in California across the pandemic period.

We found that the COVID-19 outbreak clearly influenced travel behavior, prompting reductions in trips to workplaces and other essential and non-essential locations as well as increases in "residence trips" which, as defined by the Google Mobility as staying at home or visiting places of residence. COVID-19-related policy measures appear to have influenced average travel behavior, with more stringent public health measures and more generous economic supports reducing workplace trips and increasing staying at home, especially at the beginning of the pandemic.

In contrast, behavioral factors—including public risk perception ("Panic Index") and social amplification of risk ("Sentiment Index") measures (see discussion above in Section 3.3)—appear to influence travel behavior, though this only occurred in an intuitive manner—i.e. heightened public risk perception increasing staying at home, and reducing other trips—in the post-vaccination period of the pandemic. County-level factors, such as home prices, rainfall levels, government employment, and broadband rates influence workplace and home travel behavior in statistically significant and intuitive directions. These findings have important implications for our research questions and for broader theory regarding public behavioral responses to disaster events.

As detailed in Section 3.3, a comprehensive literature review was conducted in tandem with data collection for available indicators. Using multivariate regression analysis to explore which factors were the most influential on travel behavior, we regressed these various California county-level independent variables against county-level Google Mobility data, which include daily travel to workplaces, retail locations, grocery stores and pharmacies, parks and recreation sites, transit stations, and residential locations expressed as a change from pre-pandemic levels. Results of the regressions on workplaces and residential locations are presented below.

6.1 Secondary Data Trend Analysis

This section uses trend analysis to provide a cursory examination of California travel behavior during the pandemic. As shown in Figures 38 (Los Angeles County) and 39 (California), early in the pandemic, trips to workplaces and transit stations decreased substantially. Across California, workplace trips decreased by around 50% by mid-April 2020 before softening to around a 35% reduction during the summer and fall of 2020. During the surge of winter 2020–21, workplace trips declined again to between 40% and 50% below pre-pandemic levels, before gradually increasing through 2021 to an average level of around 30% below the pre-pandemic baseline. These

workplace trip trends are similar to the trends for trips to grocery and pharmacy stores and retail stores. In contrast, "residence trips" (i.e., staying at home or visiting places of residence) increased and demonstrated a largely inverse trend to the trend for workplaces, though to a lesser degree.

Government policy measures—identified with the vertical lines in Figures 38 and 39—appear to have been particularly effective in the early pandemic period. Changes to travel behavior appear to have been influenced by a combination of policy changes and the sudden shift in public risk perception, despite relatively low COVID-19 case numbers compared to later surges. Similarly, the state's tiered system of public health measures appears to have influenced workplace travel behaviors during the summer and fall of 2020: despite case numbers declining in the fall of 2020, travel behaviors remained relatively consistent. The winter 2020–21 COVID-19 surge was met with a "Regional Stay Home Order" across many areas of the state, and again these two factors appear to have combined to influence reductions in workplace trips and increases in residential trips.

As shown in Figures 38 and 39, the link between policy, risk perception, and travel behavior appears to shift again in 2021. The rollout of the COVID-19 vaccination program in tandem with graduated relaxations of public health restrictions across California early in 2021 appear to have contributed to increasing workplace trips and declining residential trips. Moreover, when COVID-19 cases rose again during the delta variant surge of fall 2021 and the omicron variant surge of winter 2021, there appears to be only a minor impact of the pandemic on travel behavior. This suggests the link between risk perception and travel behavior had been broken by this point in the pandemic. These findings provide insight related to research questions R1 (To what extent did the COVID-19 pandemic impact telecommuting, and other commute modes in California?) and R1d (Did government policy impact travel behavior or was public risk perception of COVID-19 a more dominant factor?).

From summer 2021 onwards, travel behavior appears to have stabilized at a "new normal," and travel behaviors appear to have shifted for good. This observation provides insight into research question R2 (What will the future of telecommuting look like in California?) and especially R2b (What can pre-COVID-19 telecommuting and commute behaviors—especially across California counties and places—tell us about the future of telecommuting?). In other words, based on the data presented in Figures 38 and 39 alone, we might expect workplace trips to continue at around 30% below pre-pandemic levels, and for home presence ("residence trips") to continue at around 6% above pre-pandemic levels. However, two caveats are important here. First, neither measure is a perfect indicator of telecommuting, and instead, both measures provide partial insights into changing telecommuting rates. Second, to further answer the other key research questions about causal relationships and future projections, more rigorous statistical analyses are required, especially to control for confounding variables. These regression analyses are provided in the following sections.

6.2 County-Level Regression Analyses

This section looks at the potential pre-pandemic county-level factors influencing travel behavior at key points in the pandemic: (1) the peak of the first lockdown (April 13, 2020; California implemented the first stay at home order in March 19, 2020); (2) the peak of the summer 2020 surge (July 20, 2020, the week after state-wide restrictions were re-imposed); (3) the peak of the winter 2020–21 surge (January 13, 2021; a month after "Regional Stay Home Orders" were imposed); and (4) the end of the California tiered system (June 22, 2021; a week after the restrictions ended).

At the California county level, very few hypothesized location-specific variables appear to influence changes in travel behaviors at key moments during the pandemic, though some exceptions are notable. As shown in Table 1, for workplace trips in the summer of 2020 (in the week after a second series of restrictions were imposed), counties with higher poverty rates saw outsized reductions in workplace trips. This may indicate the disproportionate recession-related unemployment rates experienced by low-income neighborhoods in California during the pandemic. In contrast, counties with large average household sizes experienced higher-than-average workplace trips, which—according to the literature—could indicate that workers with more household members were returning to work.

For workplace trips in the winter of 2020–21 (during the height of California's third wave), counties which are more rural experienced higher-than-average workplace trips. This reflects the fact that rural counties tended to have lower case rates and hence less stringent policy measures in the tiered system. However, it is also possible that this reflects growing resistance to California's COVID-19 measures among rural communities.

As shown in Table 7, for "residence trips" across all time periods analyzed, counties with higher poverty rates saw more people staying home during the pandemic. This could reflect poorer communities increasing telecommuting rates or experiencing disproportionate levels of unemployment. Also, counties that are more rural experienced lower-than-average residential trips, but this was only statistically significant during the height of California's third wave. This is the counterpart to the above finding of rural counties tending to have higher workplace trips during this period.

Referring to the research questions, the county-level regression analysess provide some possible insights into causal influences on telework usage during the pandemic. With respect to R1e (What can spatial and locational variability—across California counties or places—tell us about the factors influencing telecommuting before and during the COVID-19 pandemic?) in particular, taking together increased "residence" trips (including staying at home) and reduced workplace trips, there is evidence to suggest that a rural-urban divide emerged, especially as the pandemic wore on. Moreover, across the entire pandemic, it appears that counties with higher levels of poverty experienced more staying at home and lower-than-average workplace trips. Given that both

dependent variables (workplace trips and residence trips) have shown similar patterns in the regression results, this suggests that telework, rather than unemployment, increased more in poorer counties. This suggests that the pandemic may have had an equalizing effect on telecommuting usage, which had been a privilege of wealthier, whiter, and higher-ranking workers before the pandemic.

These two key findings provide insights with respect to R2 (What will the future of telecommuting look like in California?) and especially R2b (What can pre-COVID-19 telecommuting and commute behaviors—especially across California counties and places—tell us about the future of telecommuting?). Despite evidence from other studies that Californians are moving away from dense urban areas to cheaper and lower-density locations in and out of state, our findings suggest that rural communities were still more likely than urban areas to increase workplace trips and decrease staying at home at later stages of the pandemic. This suggests that urban California areas may continue to be less likely to attend workplaces as we move toward the post-pandemic period. Similarly, with poorer counties appearing to have increased staying and home and avoiding workplaces compared to other counties, it is possible that this pattern, too, will continue into the post-pandemic period.

6.3 Panel Data Analyses

Panel data analysis—multivariate regression analysis on data that also varies across time periods--was undertaken to explore the influence of dynamic county-level factors on monthly travel behavior, while accounting for potential omitted variables. Based on Hausman test results, a random-effects model is applied. Three cuts of the data were used: see Tables 8 through 10. The second and third cuts (Tables 9 and 10) are used to explore whether there are differences between the pre-vaccine and post-vaccine periods of the pandemic, since our analysis above suggested these had distinctive trends.

Across the 24 months of the pandemic, as shown in Table 8, it is notable that the coefficient for the level of monthly COVID-19 cases across counties is statistically insignificant, while the number of deaths has a significant negative impact on workplace trips and a significant positive impact on residential trips. This result highlights the overall impact of COVID-19 levels on travel behavior (R1a, R1b).

Other results provide insight into R1d (Did government policy impact travel behavior or was public risk perception of COVID-19 a more dominant factor?). The coefficient for the Policy Stringency index is statistically significant for all travel behaviors and follows the intuition that more stringent policies lead to more staying at home and fewer other trips. Moreover, this index is particularly influential on all dependent variables during the first period of the pandemic: the effect size of each trip type is much larger in magnitude for the pre-vaccine period than all the pandemic (including post-vaccine) periods. For example, the effect size on workplace trips is -0.120 for the whole pandemic period (Table 8), -0.970 for the pre-vaccine period (Table 9), and

insignificant for the post-vaccine period (Table 10). These results confirm the previous univariate trend analysis findings that the various California public health measures influenced travel behavior, especially before the vaccination roll-out.

The other major policy index used in the panel data analysis is the Economic Support index. In the California context reflects the federal government's support for unemployment; hence, variations are visible across time but less so between counties. This index appears to follow intuition for the "all pandemic" period (Table 8), with higher levels of unemployment benefits leading to fewer workplace, retail, and transit trips—as newly unemployed workers could adhere to public health guidelines and avoid such trips—and more residential trips.

However, the indicators relating to the behavioral factors in our general explanatory model—namely, the panic index indicating public risk perception and the media sentiment index capturing some elements of the social amplification of risk—tell a less intuitive story. While both factors are statistically significant in their influence on most travel behaviors, for the "all pandemic" period (Table 8), they counterintuitively suggest that more panic and higher levels of media attention to pandemic news led to more workplace, retail, and grocery trips and less staying at home, which warrants further studies. There are numerous possible explanations for these results, other than the possibility of "noisy" or inappropriately specified models. Higher panic and media pandemic coverage could have caused some people to make workplaces trips to collect belongings, or retail and grocery trips to stockpile goods, despite public health guidelines. Moreover, as suggested in the "Social Amplification of Risk" framework, it is possible pandemic coverage from different media outlets is being received in different ways by different populations, or that "panic" levels are experienced in different ways by these different populations. Each of these limitations with the data could lead to inappropriately specified relationships between these two variables and travel behavior indicators. There were divergent results elsewhere too: more panic with less media coverage led to fewer park and transit trips.

To explore whether these results were caused by the time period of the specification, we compare regression results from both pre- and post-vaccine periods. The regression results identified in the previous paragraph were also broadly reflected in the pre-vaccine period with a couple of exceptions (Table 9). However, during the post-vaccine period (Table 10), the panic and media sentiment indices both largely follow intuition, with higher levels of panic and media coverage of the pandemic leading to fewer trips and more staying and home. These distinct results may be a consequence of the above finding that policy effects were more prominent in the pre-vaccine period of the pandemic, yet these same policy effects became less impactful in the post-vaccine period. One cause of the divergent pre- and post-vaccine results could be that the four indices (Policy Stringency, Economic Support, Panic, and Media Sentiment) all follow a broadly similar trend early in the pandemic—a sharp increase followed by a gradual decline thereafter. However, while the four indices were very closely clustered in the pre-vaccination period of the pandemic, the levels become much more divergent in the post-vaccination period. These different between-group variances across the periods may account for the divergent results above and allow for us to put

more weight on the post-vaccination period results, which suggest that the four indices influence travel behaviors in the hypothesized ways (i.e. higher panic, media coverage, economic support, and policy stringency all lead to more staying at home and less travel).

While our trend analysis above suggested that the presence of vaccines may have influenced travel behavior, both of our vaccination-related variables were insignificant for all but retail trips. This suggests that vaccine presence served to alleviate fears about some non-essential trips (retail), but it did not appear to influence essential grocery trips.

In a similar vein, it is notable that county-level factors appear to have significantly influenced travel behavior. Counties with more broadband access and higher home prices were more likely to have stayed at home and traveled less (including to workplaces) throughout the pandemic. While these panel data analysis findings do not entirely match the OLS county-level regression analyses—as neither broadband access nor median home prices is statistically significant in its effect on travel variables in those models—they do support the general finding that urban areas, which tend to have higher home prices, have larger increases in people staying at home and less severe decreases in workplace attendance.

Table 6. Regression on Workplace Trips for California Counties

	4/13/20	**7/20/20**	**1/13/21**	**6/22/21**
Constant	-31.221	-47.444	-33.989	-37.947
	(-0.723)	(-1.035)	(-0.795)	(-0.631)
Broadband (% of households)	0.144	0.355	0.201	0.211
	(0.454)	(1.054)	(0.641)	(0.478)
Median Housing Value	0.000	0.000	0.000	0.000
	(1.069)	(1.293)	(1.032)	(0.107)
Information Sector Employees	-1.728	-2.347	-2.089	-1.017
	(-1.088)	(-1.391)	(-1.329)	(-0.46)
Median Household Income	0.000	0.000	0.000	0.000
	(-1.698)	(-1.384)	(-0.485)	(-0.509)
Below Poverty (% people)	-0.778	-1.026*	-0.603	-0.834
	(-1.701)	(-2.113)	(-1.334)	(-1.311)
Speak No English at Home	-0.184	-0.313	-0.157	-0.065
(% people)	(-1.085)	(-1.734)	(-0.937)	(-0.275)
Advanced Degree (% over 25)	-0.613	-0.197	-1.308	-1.025
	(-0.712)	(-0.215)	(-1.535)	(-0.855)
Bachelor's degree (% over 25)	0.003	0.078	0.428	0.609
	(0.007)	(0.144)	(0.85)	(0.858)
Average Household Size	10.813	17.358*	10.329	16.289
	(1.233)	(1.865)	(1.191)	(1.335)
Work Outside County	0.060	0.089	0.027	0.104
	(0.757)	(1.053)	(0.343)	(0.939)
Public Transit to Work	0.003	-0.193	-0.375	-0.536
(% workers over 16)	(0.010)	(-0.629)	(-1.311)	(-1.333)
Mean Commute Time	-0.364	-0.473	-0.274	-0.313
(% Workers over 16)	(-1.309)	(-1.604)	(-0.997)	(-0.811)
Drive to Work	0.102	0.084	0.627	0.813
(% workers over 16)	(0.246)	(0.192)	(1.529)	(1.409)
Business Formations (2019)	0.000	0.000	0.000	0.000
	(0.287)	(0.641)	(0.449)	(0.137)
Unemployment Rate (2020)	0.525	1.521	0.503	0.726
	(0.492)	(1.341)	(0.476)	(0.488)
Urban/Rural Index	2.413	8.764	11.863*	14.158
	(0.386)	(1.321)	(1.920)	(1.628)
Vehicle Miles	-0.44	-1.235	-1.396	-1.94
	(-0.474)	(-1.253)	(-1.521)	(-1.503)
Max Download Speed	-0.029	-0.032	0.000	0.002

	4/13/20	7/20/20	1/13/21	6/22/21
	(-0.808)	(-0.86)	(-0.024)	(0.055)
N	32	33	33	33
Adj. R-squared	0.725	0.887	0.907	0.791

Note: * p<0.1; ** p<0.05; *** p<0.01

Table 7. Regression on Residence Trips for California Counties

	4/13/20	**7/20/20**	**1/13/21**	**6/22/21**
Constant	-5.448	-9.248	-9.369	-3.144
	(-0.261)	(-0.43)	(-0.655)	(-0.147)
Broadband (% of households)	0.144	0.059	0.126	0.003
	(0.939)	(0.376)	(1.199)	(0.019)
Median Housing Value	0.000	0.000	0.000	0.000
	(0.296)	(-0.248)	(0.201)	(-0.798)
Information Sector Employees	0.963	1.195	0.862	1.094
	(1.256)	(1.513)	(1.639)	(1.396)
Median Household Income	0.000	0.000	0.000	0.000*
	(1.389)	(1.53)	(1.227)	(1.873)
Below Poverty (% people)	0.506*	0.479*	0.339*	0.431*
	(2.295)	(2.106)	(2.243)	(1.909)
Speak no English at Home	0.038	0.052	0.06	-0.017
(% people)	(0.471)	(0.623)	(1.073)	(-0.208)
Advanced Degree (% over 25)	0.535	0.177	0.336	0.441
	(1.288)	(0.415)	(1.178)	(1.038)
Bachelor's Degree (% over 25)	-0.291	-0.090	-0.122	-0.238
	(-1.185)	(-0.358)	(-0.724)	(-0.949)
Average Household Size	-5.625	-4.023	-4.156	-4.967
	(-1.33)	(-0.923)	(-1.431)	(-1.148)
Work Outside	-0.050	-0.023	-0.015	-0.022
	(-1.311)	(-0.584)	(-0.59)	(-0.584)
Public Transit to Work	0.037	0.066	0.08	0.037
(% workers over 16)	(0.266)	(0.463)	(0.844)	(0.263)
Mean Commute Time	0.303*	0.192	0.141	0.214
(% Workers over 16)	(2.259)	(1.389)	(1.538)	(1.558)
Drive to Work	-0.126	-0.074	-0.135	-0.087
(% workers over 16)	(-0.629)	(-0.361)	(-0.988)	(-0.425)
Business Formations (2019)	0.000	0.000	0.000	0.000
	(0.306)	(-0.448)	(0.138)	(-0.373)
Unemployment Rate (2020)	-0.484	-0.327	-0.268	-0.016
	(-0.939)	(-0.617)	(-0.757)	(-0.03)
Urban/Rural Index	-4.722	-4.527	-4.274*	-4.715
	(-1.566)	(-1.458)	(-2.065)	(-1.529)
Vehicle Miles	0.442	0.370	0.444	0.334
	(0.988)	(0.802)	(1.445)	(0.73)
Max Download Speed	0.006	-0.003	-0.006	-0.001

	4/13/20	7/20/20	1/13/21	6/22/21
	(0.369)	(-0.217)	(-0.513)	(-0.095)
N	33	33	33	33
Adj. R-squared	0.939	0.922	0.963	0.889

Note: * p<0.1; ** p<0.05; *** p<0.01

Figure 38. COVID-19 Cases and Travel Behavior in Los Angeles County

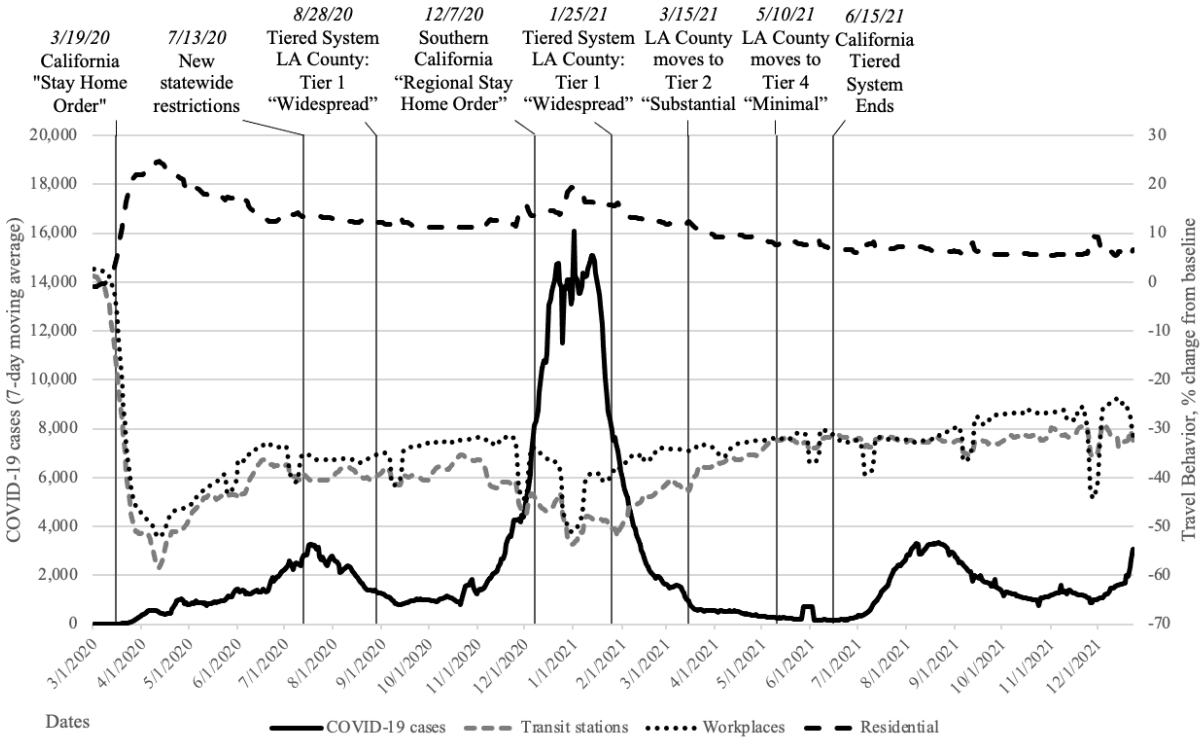


Figure 39. COVID-19 Cases and Travel Behavior in California

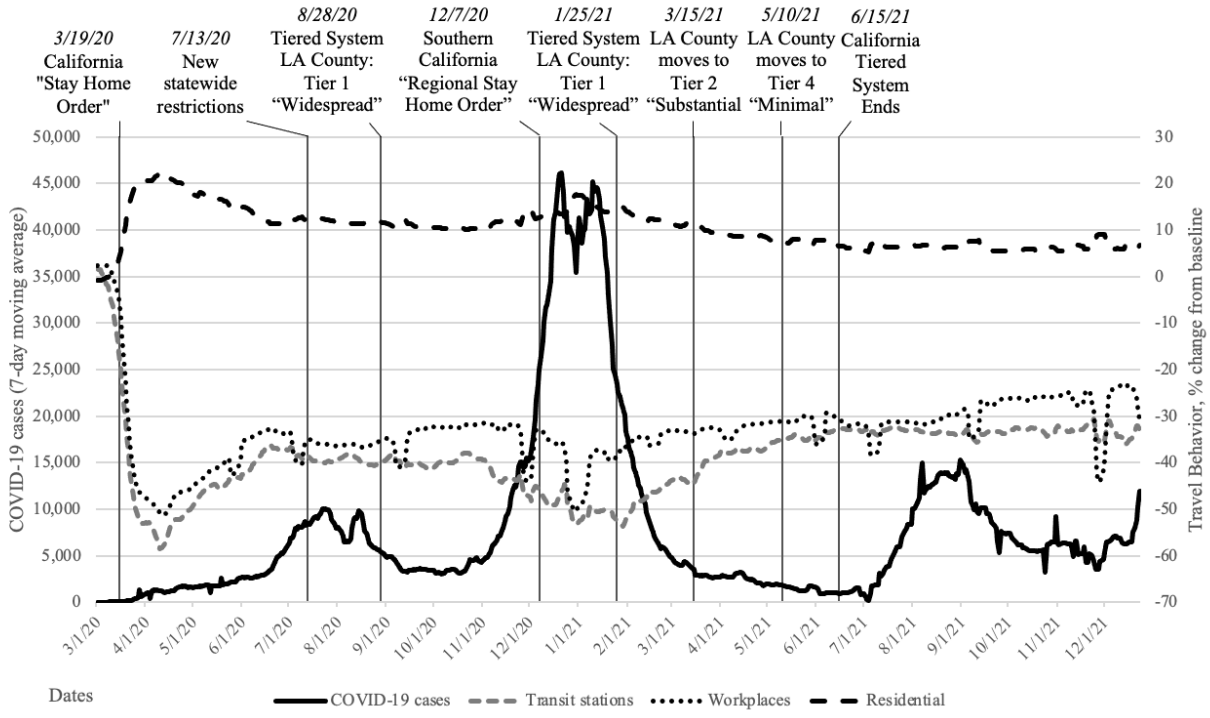


Table 8. Panel Data Analysis of Monthly County-Level Travel Behavior, February 2020 – January 2022

	Workplace	Retail	Grocery	Parks	Transit	Residential
Cases	-0.000	-0.000	-0.000	0.000	0.000	-0.000
	(1.02)	(0.15)	(0.10)	(0.36)	(0.24)	(0.14)
Deaths	-0.031	-0.010	-0.036	-0.107	-0.111	0.027
	(1.82)*	(0.29)	(1.20)	(1.18)	(2.33)*	(3.53)**
Doses	-0.000	-0.000	-0.000	0.000	0.000	-0.000
	(0.92)	(2.02)*	(0.46)	(0.18)	(1.35)	(0.13)
Fully Vaccinated	0.000	0.001	0.000	0.000	-0.000	-0.000
	(0.80)	(2.61)**	(0.71)	(0.59)	(0.86)	(1.69)
Rainfall	-0.202	-0.707	-0.429	-3.763	-1.035	0.200
	(3.54)***	(6.25)**	(4.21)**	(11.77)**	(5.51)**	(7.52)**
Median Home	-0.000	-0.000	-0.000	-0.000	-0.000	0.000
Prices	(6.70)***	(5.06)**	(4.69)**	(0.15)	(1.74)	(5.31)**
Government	-0.000	-0.000	-0.000	-0.000	-0.000	0.000
Employees	(3.33)***	(2.23)*	(1.28)	(0.68)	(0.05)	(2.24)*
Employment	0.000	0.000	0.000	-0.000	-0.000	-0.000
	(2.80)***	(1.55)	(0.85)	(0.15)	(0.02)	(1.26)
Broadband	-48.225	-61.690	-57.614	-35.097	-254.750	27.654
	(6.46)***	(4.20)**	(4.37)**	(0.68)	(5.20)**	(6.93)**
Panic Index	0.579	3.395	1.075	-9.859	-0.236	-0.533
	(2.02)**	(5.99)**	(2.10)*	(6.13)**	(0.27)	(3.91)**
Media Sentiment	0.119	0.509	0.192	0.218	0.280	-0.128
Index	(6.33)***	(13.70)**	(5.70)**	(2.09)*	(4.84)**	(14.48)**
Policy Stringency	-0.120	-0.475	-0.516	-1.607	-0.430	0.153
Index	(4.92)***	(9.86)**	(11.81)**	(11.57)**	(5.73)**	(13.32)**
Economic	-0.448	-0.420	0.280	1.777	-0.101	0.106
Support Index	(13.62)***	(6.45)**	(4.74)**	(9.49)**	(1.00)	(6.77)**
Time Trend	0.439	1.357	-0.277	-4.249	-0.516	-0.230
	(5.67)***	(8.85)**	(1.99)*	(9.64)**	(2.14)*	(6.24)**
Constant	46.237	71.105	64.940	107.267	236.595	-28.603
	(7.67)***	(5.97)**	(6.07)**	(2.51)*	(5.72)**	(8.72)**
R-squared	0.73	0.65	0.44	0.23	0.48	0.75
N	1,344	1,277	1,239	1,156	1,067	1,151

Note: * p<0.1; ** p<0.05; *** p<0.01

Table 9. Panel Data Analysis of Monthly County-Level Travel Behavior, February 2020 – February 2021

	Workplace	Retail	Grocery	Parks	Transit	Residential
Cases	-0.001	0.000	0.002	0.002	-0.001	0.000
	(1.61)	(0.06)	(1.60)	(0.61)	(0.42)	(0.16)
Deaths	-0.062	-0.070	-0.156	-0.471	-0.060	0.037
	(1.41)	(0.75)	(1.80)	(1.69)	(0.44)	(1.93)
Doses	0.001	0.001	0.001	0.004	0.001	-0.000
	(2.43)**	(0.92)	(0.99)	(1.89)	(0.70)	(2.49)*
Fully Vaccinated	-0.002	-0.001	-0.001	-0.007	-0.002	0.001
	(2.16)**	(0.80)	(0.56)	(1.54)	(0.67)	(1.98)*
Rainfall	0.298	-0.514	-0.503	-4.852	-1.683	0.067
	(2.55)**	(2.01)*	(2.11)*	(6.07)**	(3.51)**	(1.19)
Median Home	-0.000	-0.000	-0.000	-0.000	-0.000	0.000
Prices	(8.45)***	(7.08)**	(5.55)**	(1.50)	(4.20)**	(11.70)**
Government	-0.000	-0.000	-0.000	-0.000	-0.000	0.000
Employees	(2.83)***	(2.68)**	(2.59)**	(1.43)	(1.98)*	(3.72)**
Employment	0.000	0.000	0.000	0.000	0.000	-0.000
	(2.55)**	(2.24)*	(2.33)*	(0.91)	(1.90)	(2.91)**
Broadband	-40.611	-22.991	-38.299	9.474	-173.390	18.558
	(5.31)***	(1.49)	(2.76)**	(0.15)	(3.83)**	(4.80)**
Panic Index	2.030	2.479	-2.292	-18.039	-1.842	-0.762
	(5.65)***	(3.13)**	(3.08)**	(7.37)**	(1.52)	(4.41)**
Media Sentiment	0.207	0.321	-0.094	-0.645	0.057	-0.125
Index	(6.22)***	(4.38)**	(1.36)	(2.83)**	(0.50)	(7.78)**
Policy Stringency	-0.970	-1.497	-1.098	-3.572	-1.188	0.490
Index	(17.38)***	(12.33)**	(9.75)**	(9.51)**	(6.27)**	(17.98)**
Economic	0.227	0.578	1.099	4.252	0.762	-0.194
Support Index	(3.57)***	(4.14)**	(8.44)**	(9.81)**	(3.52)**	(6.26)**
Time Trend	-0.041	0.108	-2.320	-9.189	-2.063	0.110
	(0.35)	(0.42)	(9.70)**	(11.53)**	(5.19)**	(1.96)*
Constant	50.135	54.914	62.427	108.985	187.798	-26.800
	(8.14)***	(4.39)**	(5.53)**	(2.16)*	(4.98)**	(8.44)**
R-squared	0.84	0.68	0.47	0.30	0.59	0.86
N	728	694	678	627	575	612

Note: * p<0.1; ** p<0.05; *** p<0.01

Table 10. Panel Data Analysis of Monthly County-Level Travel Behavior, March 2021 – January 2022

	Workplace	Retail	Grocery	Parks	Transit	Residential
Cases	-0.001	0.001	0.001	0.003	0.001	-0.000
	(3.95)***	(1.80)	(2.24)*	(2.48)*	(1.27)	(0.20)
Deaths	0.282	-0.319	-0.276	-1.083	-0.312	0.019
	(3.61)***	(1.85)	(1.77)	(2.08)*	(1.24)	(0.64)
Doses	-0.000	0.000	0.000	0.000	0.000	0.000
	(0.92)	(1.28)	(1.37)	(1.20)	(0.90)	(1.79)
Fully Vaccinated	-0.000	-0.000	-0.000	-0.001	-0.001	0.000
	(1.52)	(1.63)	(0.90)	(1.11)	(2.16)*	(1.54)
Rainfall	-0.031	-0.248	-0.297	-3.049	-0.548	0.082
	(0.73)	(2.56)*	(3.35)**	(10.01)**	(3.42)**	(4.81)**
Median Home	-0.000	-0.000	-0.000	-0.000	-0.000	0.000
Prices	(6.01)***	(4.94)**	(3.14)**	(0.99)	(1.22)	(7.46)**
Government	-0.000	-0.000	-0.000	-0.000	0.000	-0.000
Employees	(1.82)*	(1.73)	(1.14)	(1.09)	(0.79)	(0.09)
Employment	0.000	0.000	0.000	0.000	-0.000	0.000
	(1.31)	(1.19)	(0.57)	(0.45)	(0.81)	(0.12)
Broadband	-41.770	-87.370	-90.665	-28.144	-278.858	15.026
	(4.76)***	(4.50)**	(4.69)**	(0.47)	(4.47)**	(3.75)**
Panic Index	-5.973	-5.525	-3.663	-22.033	-7.698	3.118
	(12.15)***	(4.95)**	(3.57)**	(6.21)**	(4.35)**	(15.85)**
Media Sentiment	-0.118	0.294	0.265	0.221	0.181	-0.045
Index	(7.46)***	(8.16)**	(8.00)**	(1.96)*	(3.15)**	(7.12)**
Policy Stringency	0.007	-0.437	-0.370	-1.254	-0.226	0.100
Index	(0.38)	(10.81)**	(9.93)**	(9.62)**	(3.47)**	(13.99)**
Time Trend	-0.755	-1.295	-0.838	-6.829	-1.807	0.485
	(8.51)***	(6.42)**	(4.51)**	(10.64)**	(5.63)**	(13.60)**
Constant	30.778	116.166	114.048	188.377	256.336	-23.121
	(4.28)***	(7.22)**	(7.10)**	(3.77)**	(4.86)**	(7.01)**
R-squared	0.69	0.62	0.52	0.27	0.45	0.76
N	616	583	561	529	492	539

Note: * p<0.1; ** p<0.05; *** p<0.01

7. Summary & Conclusions

We have applied several approaches, including state-level surveys and interviews as well as regression and time-series analyses, to uncover the relationships, patterns, and trends of telecommuting and the "tele-" components of transportation, employment, land use, and emissions before and during, as well as preferences after the COVID-19 pandemic. Table 11 summarizes the major findings. Then, we separately discussed the findings based on each method.

Table 11. Summary Results for Each Method and Across Each "Tele-" Element

"Tele-" Element	Major Findings
Transportation	• Trends show an inverse relationship between staying at home and transport usage, though the latter changed by much larger amounts. • The state-level surveys (administered to employees) show that telecommuting has been widely adopted and is likely to continue for at least three years (Note: the three-year time frame was simply a reflection of the way questions were framed). • The state-level interviews (administered to employers, i.e. managers and executives) confirm that workplace cultures across industries have shifted in ways that would likely see more working from home and fewer vehicles on the road. • Regression results suggest that pre-pandemic county-level factors, especially poverty levels, influenced staying at home and transportation behaviors. • Panel data analysis suggests that changing policy stringency and economic support levels, as well as county-level factors, especially broadband and higher home prices influence, all travel behaviors. These influences shifted during the pandemic, with policy and risk perception factors appearing to play a more dominant role early in the pandemic, while the roll-out of vaccines appears to have reduced the importance of policy and risk perception factors on travel behaviors.
Employment	• Surveys and interviews highlight the benefits and costs of working from home for employees and organizations alike. • Telecommuting may motivate people to have a dedicated workspace at home, to have more flexibility in scheduling, to receive more training and support for telecommuting, and to improve working performance. • Telecommuting may alleviate pressure for those working in high-living-cost areas. • Telecommuting enhances the quantity and quality of the talent pool and reduces the costs of hiring and employment. • However, telecommuting may make people feel more isolated and it is difficult to separate home and work life when working from home. • Telecommuting requires a transition period, training, and mentoring new employees remotely. • Telecommuting may hinder collaboration and require project management tools. • Telecommuting may complicate employment because of telecommuting feasibility, as well as tax and regulatory matters.
Land Use	• Telecommuting may motivate companies/organizations to rethink their strategies of reducing, consolidating, or rearranging office spaces. • Despite evidence from other studies that Californians are moving away from dense urban areas to cheaper and lower-density locations in and out of state, our findings suggest that rural communities were still more likely than urban areas to increase workplace trips and decrease staying at home at later stages of the pandemic.

"Tele-" Element	Major Findings
	• This implies that urban California areas may continue to be less likely to attend workplaces as we move into the post-pandemic period. • Similarly, with poorer counties appearing to have increased staying at home and avoiding workplaces compared to others, it is possible that this effect too will continue into the post-pandemic period.
Emissions	• All the above findings suggest that fewer cars on the road in general and during commute hours in particular would lead to a reduction in emissions. • Statistical data suggest that these changes occurred across numerous travel behaviors, so there is not strong evidence that commute trips were offset with local trips to grocery stores (etc.) during the pandemic. • However, public transit usage also declined during the pandemic. • Future studies are needed to explore the relationship between telecommuting and emissions.

7.1 Overall Telecommuting Patterns from the State-Level Surveys

This section summarizes the major findings about the telecommuting patterns and trends among survey respondents. These findings offer great insights into designing telecommuting policies and improving telecommuting experience in the future.

We have leveraged the crowd-sourced online platform (i.e., Amazon Mechanical Turk) to retrieve a valuable dataset of survey responses across California (n=1,985). This approach provides promising applications for increasing survey sample sizes across large geographies and economies, which will shed more light on telecommuting experience and preferences.

Among our surveys, most of the respondents were Caucasian/White, 25–34-year-old, with Bachelor or undergraduate degree, and household income of $50,000–$74,999, full-time employed, married, with no children, one car, 3–4 people in the household, and very good overall health status. This profile enables us to explore telecommuting experience in the context of travel behavior, work experience, and surrounding environment.

7.1.1 Travel Behavior

Not surprisingly, most of the respondents fully switched from driving to work alone five days per week to telecommuting (working from home) since the beginning of COVID. Noticeably, more females, older respondents (44–64-year-old age bracket) worked at home fully across the whole week indicating that these groups are more likely to fully telecommuting given their vulnerability to the virus spread. Similarly, during COVID, fewer respondents chose to carpool, ridehail, take public transit, walk, or use other transportation modes. This finding may be explained by the unsafe perception and decreased operation frequency (e.g., public transit) during the pandemic. In comparison, driving alone was still the most popular transportation mode for commuting, regardless of number of days per week suggesting the car-dependent travel pattern in California.

Before COVID, most respondents had a commute distance of 6–20 miles and a commute time of 10–40 minutes; the range of these values implies a vast difference between home and work locations. Due to the heavily increased telecommuting rate in the beginning of the pandemic, 55% of respondents found that traffic congestion has improved since COVID. These results suggest that telecommuting adoption and promotion may help alleviate the traffic pressure and related air pollution emissions. In terms of transportation infrastructure (e.g., bus stops, bike lanes), there was an unequal distribution among the respondents indicating that the built environment disparity issue may affect how people travel as well as the telecommuting patterns.

7.1.2 Work Experience

Our survey samples were retrieved from most counties across California with most respondents living and working in South California and the Bay Area. This is another evidence that the use of Amazon Mechanical Turk could help draw a comparatively representative sample of survey respondents across large geographies. Most respondents were working in the industries of information, educational services, health care, and professional/business services with most males working in information industry; 70% of respondents worked in companies/organizations with 26–250 employees or more. This working profile suggests that the survey respondents may be more telecommuting-compatible as compared to the general public.

In terms of telecommuting, before COVID, less than a quarter of the workforce was telecommuting while the telecommuting percentage of the workforce reached 26% to 100% during COVID. This result matches the expectation that telecommuting would increase with the pandemic. On the other hand, the increase of telecommuting rates was accompanied with job changes. For example, 40% of respondents started a new job during COVID; those who did not start a new job claimed that remote work policies impact their decisions. This implies that offering flexible and friendly telecommuting policies may help maintain employment stability.

In general, 45% of respondents were working in a management position, which offers great insights into telecommuting experience between management and non-management positions. We found that respondents who did not have a management position were more likely to be females, Asian or Hispanic/Latino groups, single or divorced, and with fair health condition. This result reveals an inequitable pattern within employment, which affects the experience of telecommuting. For example, 44% respondents did not have better equipment and internet access to work from home during COVID as compared to before COVID, particularly among younger respondents (e.g., 18–35-year-old), Hispanic/Latino and Black/African American groups, respondents with lower education degrees, respondents with household income < $74,999, part-time employed, full-time and part-time student respondents, single and divorced respondents, and respondents with fair health condition. This also reflects an existing inequity issue that matched our research assumptions. Therefore, telecommuting policies need to be targeted to accommodate younger people, people of color, people with lower education attainment, low income, and single status, most of whom are from disadvantaged communities.

Additionally, more than 50% respondents had a dedicated workspace at home, had more flexibility to choose their own schedules, had received adequate training and support for telecommuting, improved their working performance since the beginning of COVID but felt isolated and found it difficult to separate home and work life when working from home during COVID. These results suggest that telecommuting did provide some benefits in working experience but warrants further considerations in community development and work-life balance. Similarly, we identified some equity-related patterns in telecommuting. For example, older respondents (e.g., 65–74-year-old) and Black/African American respondents were more likely to feel isolated when working from home, which necessitates the improvement of future telecommuting policies.

During COVID, 31% of respondents' workplace moved to partial work from home, 20% respondents' workplace moved to permanent work from home, and 29% had no change. This pattern indicates that while telecommuting may be preferred and promoted by some employers and employees, the adoption practice may differ. That is, telecommuting policies should be tailored to different needs and contexts. Ideally, 25% of respondents preferred fully working from home and 25% respondents preferred working for 3 days in the office over the next three years suggesting that there was a different flavor in adopting telecommuting in the future. Only 14% of respondents wanted to work fully in the office over the next three years.

Interestingly, such preference differed when we conducted stratified analyses. Noticeably, females, Hispanic/Latino and Asian respondents, respondents with high school, professional degree, or some college education, respondents with household income of < $25,000 and > $200,000, full-time students, part-time employed, and respondents not working, single and divorced respondents, respondents with no children or 3 or more children, respondents with 2 or more cars, and respondents with fair and poor health conditions ideally preferred fully working from home over the next three years. These results reveal the fact that different population groups may have considerations that deserve further exploration. That is, why did they prefer fully telecommuting than partial telecommuting?

In comparison, respondents with Bachelor/undergraduate or master's degree, respondents with household income of $25,000-$99,999, married respondents, respondents with 1 or 2 children, respondents with 1 car in the household, and respondents with excellent and very good conditions ideally preferred working 3 days in the office. This preference may reveal the capability of working in the office among different population groups.

In terms of employers' office, 43% of respondents expected no change over the next three years, and 24% of respondents expected the office space to be reduced by more than 26%. The office space expectation may further reflect the telecommuting adoption and preferences as well as the future planning of land uses (e.g., commercial spaces).

7.1.3 Surrounding Environment

We have retrieved a balanced sample of survey respondents who owned and rented their homes. Particularly, younger respondents (e.g., 18–24-year-old), Asian, Black/African American, and Hispanic/Latino respondents, non-full-time employed respondents, single and divorced respondents, respondents with no car in the household, and respondents with fair and poor health conditions were more likely to rent their homes, which may suggest the likelihood to adopt telecommuting practices.

In terms of home environment, 31% of respondents' home was 901–1,200 square feet, and 38% respondents had moved residences during COVID. Out of the respondents who moved residences during COVID, 24% respondents had more space for the new home and 29% respondents rented the new home. However, there is a divided opinion on whether working from home affected the decision to move home. This did support our assumption that telecommuting could affect where people live and work.

7.2 Overall Telecommuting Patterns from the State-Level Interviews

7.2.1 Historical and Current Patterns of Telecommuting

Before COVID-19, several companies did not have an official telecommuting policy. Some companies had already started flexible and remote work before the pandemic.

When the pandemic started to affect business operations, firms shifted their office staff to full/hybrid telecommuting, while essential or field operations remained in person. Given that many companies did not have an official telecommuting policy before COVID-19, they started developing such a policy during the pandemic.

After converting to a full/hybrid telecommuting mode, several interviewees reported that their productivity remained the same or increased during the pandemic, except for the first few months of the transition period to the telecommuting mode. They indicated that the primary challenges of telecommuting include training people and mentoring new employees remotely. Collaboration is hard to achieve online, especially at projects' initial stages. Some apps and software programs such as Wrike, Monday.com, and Miro Board are used to assist project management.

Several interviewees, especially those working in areas with high costs of living such San José, indicated a strong preference to stay in the telecommuting mode in the post-COVID-19 period because of significantly lower commuting costs and better quality of life. They indicated that the option of telecommuting enhances the quantity and quality of the talent pool and reduces the costs of hiring and employment. They also mentioned that several job applicants inquired about the feasibility of telecommuting during the job interviews, and some turned down job offers when telecommuting was not an option. Nonetheless, some organizations/companies, especially those

affiliated with the California state government, have concerns about hiring people outside California because of tax and regulatory matters.

Some interviewees mentioned that their colleagues and/or senior management have moved to other states, such as Idaho, Arizona, Florida, and Texas, with no plan to move back to California in the near future. Some employers indicated that they had stopped expanding, reducing, or rearranging the office space during COVID-19. Some interviewees have consolidated office locations; some have adopted hoteling, in which employees dynamically schedule their use of workspaces.

Several companies ask employees to provide vaccination records. However, being fully vaccinated is not an official requirement according to the interviewees. A few companies provided incentives to encourage employees to get vaccinated.

7.2.2 Future Trends in Telecommuting

The advent of the pandemic has accelerated the trend toward more flexible working practices. Based on the interviews, companies that have reduced, consolidated, or rearranged their office space would remain at the same office space after COVID-19. Some companies have lost talent during the pandemic because other companies offer a similar salary with a full work-from-home option. They believe that they will be able to keep or even attract more talent if telecommuting is an option.

To design workforce development programs that train managers and workers for success when using flexible work practices, some interviewees emphasized the need to maintain strong company culture by enhancing interpersonal relationships and trust and building connections among people virtually. It is essential to develop time management and prioritization skills that maximize employees' effectiveness in response to distractions at home.

The COVID-19 pandemic has motivated stakeholders in California to rethink and revisit telecommuting policies. This study reveals the advantages and disadvantages of telecommuting from both surveys and interviews and unveils the complex relationships among the COVID-19 outbreak, government policy, public risk perception, economic factors, and travel behaviors. This study calls for state-wide and regional policy makers to plan for telecommuting policies to adapt to the new patterns.

7.3 Overall Telecommuting Patterns from the Regression Analyses

Early in the pandemic, there were substantial decreases in trips to workplaces, grocery and pharmacy stores, retail stores, and on transit. In contrast, "residence trips" (i.e., staying at home rather than traveling) increased, and while these patterns have trended toward pre-COVID rates, travel behaviors appear to have shifted for good implying the potential impacts of the pandemic.

The relationships between the COVID-19 outbreak, government policy, public risk perception, economic factors, and travel behaviors are complex, interactive, and dynamic. For example, early shifts in travel behavior appear to have been influenced by policy (e.g., California "Stay Home Order" triggering reductions in workplace trips and increases in "residence trips"). Despite COVID-19 cases, hospitalizations and deaths being relatively low in the early period, high levels of risk perception, high unemployment rates, and increased federal government transfers all influenced behaviors in that early period. Moreover, as California policy shifted in response to COVID-19 surges and declines, travel behavior responses appear to have been influenced by both factors simultaneously. In general, a "new normal" appears to have emerged. Despite Delta and Omicron surges in fall and winter 2021, respectively, travel behavior has not shifted significantly. This suggests that public risk perception is no longer a mediating factor, influenced by the roll out of COVID-19 vaccinations from December 2020 onwards.

At the California county level, very few hypothesized location-specific variables influence changes in travel behaviors at key moments during the pandemic. Some exceptions include: For workplace trips in the summer of 2020 (in the week after a second series of restrictions were imposed) counties with higher poverty rates saw outsized reductions in workplace trips. In contrast, counties with large average household sizes experienced higher than average workplace trips. For workplace trips in the winter of 2020–21 (during the height of California's third wave) counties which are more rural experienced higher than average workplace trips. For "residence trips" across all time periods analyzed, counties with higher poverty rates saw more people staying home during the pandemic. This could reflect poorer communities increasing telecommuting rates or experiencing disproportionate levels of unemployment.

Also, for "residence trips" (but only statistically significant during the height of California's third wave), counties that are more rural experience lower than average workplace trips. For trips to grocery stores and pharmacies, the only significant and impactful positive relationship was observed for counties with higher poverty rates.

7.4 Limitations and Future Work

Our study has several limitations. For example, since we have leveraged a crowd-sourced online platform to conduct surveys across residents across California, our survey respondents were limited to online users. That is, respondents who have no access to Amazon Mechanical Turk (e.g., a valid Amazon account) were not included in the survey. Therefore, our survey sample may not fully represent the attitudes of the general population. In terms of survey results, respondents who tend to work at home may be more likely to contribute to the surveys. Lastly, only 2,000 responses were solicited due to budget constraints. Future studies may incorporate traditional offline surveys into the survey approach and conduct a comparison between online and offline responses, which may help reflect telecommuting patterns and trends among different survey respondents with various socioeconomic positions.

Similarly, due to budget constraints, we were able to conduct target interviews for a small sample of 28 interviewees among major stakeholders within 10 industries. While this may not offer representative answers for each industry, it helps reflect attitudes and policies about telecommuting during the COVID-19 pandemic. Additionally, our interview data may not specify the exact telecommuting trends in the future. Future studies would be expanded to invite more interviewees from more industries and to include more interview questions to better inform future telecommuting patterns and policies.

One limitation noted across the telecommuting literature is the patchwork of data and evidence used to explore the phenomena. As discussed in the literature review, U.S. Census data provide estimates annually and only for the full-time work from home mode. The National Household Travel Survey provides more detailed data on different flexible workplace practices, such as part- and full-time telecommuting, flexible start times, self-employment, and work locations. However, the surveys are not conducted annually, and the years between each survey—2017, 2009, 2001, 1995—are not consistent. Numerous other data have been collected across different regions, occupations, and periods; however, until the Google Mobility data became available, no other frequent, consistent, and county-level data were publicly available, and none have yet been published for the period during the pandemic. Even then, the Google Mobility data are limited because the workplace and residence trips are both imperfect indicators of telecommuting.

Further county-level and city-level analysis is also needed. There 58 California counties, and data on all variables is not collected for all counties as some counties have lower than 35,000 population threshold as defined by the Census publication. This means our current analysis has a sample size of 33 counties. To address this issue, city-level data have been collected across numerous independent variables; however, the Google Mobility data are only available at the county level. Other dependent variables representing telecommuting would need to be collected at the city level, and ideally during the pandemic period. Even with the current county-level data, further analysis is needed to explore whether variables should be dropped from the modeling or including additional variables.

Further panel data analysis should be undertaken to unpack the current findings. For example, the urban-rural divide identified above may be driven in part by political opinion among electorates within these counties. As such, investigating political voting patterns across counties, and hopefully across time, may provide further insight. We might also include measures of labor market tightness, to see the extent to which extent labor supply issues may have influenced travel behaviors in general and telecommuting specifically.

Appendix A

State-Level Surveys

California Telecommuting Study

You are being asked to participate in a research study on telecommuting (e.g., remote working, distance working, telework, working from home). Before you give your consent to the researchers, it is important that you read the following information to understand what you will be asked to do.

Investigators: A group of researchers from California State University, Dominguez Hills is directing this study.

Purpose of the Study: This survey is designed to explore the telecommuting (the practice of working from home) patterns before, during, and after the COVID-19 pandemic across California. The intention is to improve understanding of impacts, barriers, and strengths of telecommuting.

Description of the Study: If you are 18 years or older and live in California, please answer the following questions about your experience with telecommuting in relation to demographics, travel, and employment patterns. This survey takes about 10-15 minutes to complete, and all personally identifiable information will be confidential.

Risks or Discomforts: Participation in this study is voluntary. If you begin to feel uncomfortable, you may discontinue participation at any time, either temporarily or permanently.

Benefits and Incentives of the Study: Participants may contribute to the study's success to determine the major impacts and patterns of telecommuting. If you complete the survey, you will receive the corresponding compensation as set forth by the Amazon Mechanical Turk task.

Questions about the Study: Should you have any questions about this survey, you may contact the principal investigator: Dr. Tianjun Lu, email: tilu@csudh.edu

By checking "YES" to the checkbox below, you consent to participate in this study.

☐ YES, I live in California and consent to participate; ☐ NO, I do not consent to participate.

Section 1: Getting Around

Please indicate how many days a week you use the following modes to commute to work. Before COVID-19 (Before December 2019); if you have not used that mode to get to work, please choose "0".

	0	1	2	3	4	5	6	7
Drive alone								
Carpool								
Ridehail (e.g., Uber, Lyft)								
Public transit								
Bike								
Walk								
Other								

During COVID-19 (After December 2019):

	0	1	2	3	4	5	6	7
Drive alone								
Carpool								
Ridehail (e.g., Uber, Lyft)								
Public transit								
Bike								
Walk								
Other								

How many miles is your commute to work (one way)? If you are not sure, please provide your best guess. Before COVID-19 (Before December 2019):

☐0-5

☐6-20

☐21-40

☐41-60

☐61 or more

During COVID-19 (After December 2019):

☐0-5

☐6-20

☐21-40

☐41-60

☐61 or more

How many minutes does it usually take you to get from home to work (one way, door to door)?

Before COVID-19 (Before December 2019):

_____

During COVID-19 (After December 2019):

_____

How many approximate total miles of non-work trips on average (e.g., shopping, errands) do you travel?

Before COVID-19 (Before December 2019):

During weekdays:_____

During weekends:_____

During COVID-19 (After December 2019):

During weekdays:_____

During weekends:_____

Please choose the response that best describes your situation now.

	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree
I like biking and walking to work but the infrastructure (e.g., bike lane) makes it difficult					
There are no bus stops near my home					
Traffic congestion has improved since the start of COVID-19					
Please select "somewhat agree" here					

Section 2: Your Work

What is your current work status (Check all that apply)?

☐ Full-time employed ☐ Part-time employed ☐ Full-time student

☐ Part-time student ☐ Homemaker ☐ Retired

☐ Not working ☐ Other

Which county do you work in? If you are a full-time student, you can indicate the county in which you attend school. Please provide your zip code as well. If you are not working or working from home, please fill in your home information.

County: _____

Zip code: _____

Which industry are you working in?

☐ Natural Resources ☐ Information ☐ Professional/Business Services

☐ Construction ☐ Financial Activities ☐ Educational Services

☐ Manufacturing ☐ Health Care ☐ Leisure and Hospitality

☐ Wholesale Trade ☐ Government ☐ Other Services

☐ Retail Trade ☐ Transportation/Utilities ☐ Other (please specify)_____

What is the size of the organization/company for whom you work?

☐ Very small (< 25 employees) ☐ Mid-size (25-250 employees)

☐ Very large (> 250 employees) ☐ Not applicable

How many hours do you work per week?

Before COVID-19 (Before December 2019):

_____

During COVID-19 (After December 2019):

_____

Does your job provide free parking or parking reimbursement?

Before COVID-19 (Before December 2019):

☐ Yes ☐ No ☐ Uncertain

During COVID-19 (After December 2019):

☐ Yes ☐ No ☐ Uncertain

What percentage of the workforce from your job is telecommuting?

Before COVID-19 (Before December 2019):

☐ 0-25% ☐ 26-50%

☐ 51-75% ☐ 76-100% ☐ Uncertain

During COVID-19 (After December 2019):

☐ 0-25% ☐ 26-50%

☐ 51-75% ☐ 76-100%

Were you furloughed from your job during the pandemic?

☐ Yes ☐ No

Did you start a new job during the pandemic?

☐ Yes ☐ No

If you have started a new job or seek new employment, is it because of the remote work policies?

☐ Yes ☐ No ☐ Not applicable

The following questions ask you to compare your current job to your job prior to the COVID-19 pandemic (before December 2019). Please choose the response that best describes your situation now.

	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree	Not applicable
I am working in a management position						
I have better equipment and internet access to work from home now						
I have received adequate training and support for telecommuting during COVID-19						
I have a dedicated workspace at home						
I have more flexibility to choose my own schedule now						
My working performance improved since working from home						
I feel isolated when I work from home						
I find it difficult to separate home and work life when I work from home						
Please select "strongly agree" here						

How did your workplace change operations during COVID-19 (After December 2019)?

☐ Ending office lease

☐ Moving to a new location

☐ Moving to permanent work from home

☐ Moving to partial work from home

☐ No change

☐ Other (please specify)_____

How many days a week would you ideally prefer to commute to work over the next three years?

☐ 0 (fully working from home)

☐ 1

☐ 2

☐ 3

☐ 4

☐ 5 (fully working in the office)

How do you expect your employer's office space to change over the next three years?

☐ Reduce between 5 and 25%

☐ Reduce by more than 26%

☐ Stay about the same

☐ Increase between 5 and 25%

☐ Increase by more than 26%

Section 3: Surrounding Environment

Which county do you live in? Please provide your zip code as well.

County: _____

Zip code: _____

Do you own or rent your home?

☐ Own ☐ Rent

What is the size of your home?

☐ Less than 600 sq. ft.

☐ 601 - 900 sq. ft.

☐ 901 - 1,200 sq. ft.

☐ 1201 - 1,500 sq. ft.

☐ More than 1,500 sq. ft.

Did you move residences during COVID-19 (After December 2019)?

☐ Yes ☐ No

If you did move during COVID-19, did your new home have more or less space?

☐ More ☐ Less ☐ Not applicable

If you did move during COVID-19, was your new home rented or purchased?

☐ Rented ☐ Purchased ☐ Not applicable

Did working from home affect your decision to move?

☐ Yes ☐ No ☐ Not applicable

How many people live in your household (including yourself)?

☐ 1-2

☐ 3-4

☐ 5-6

☐ More than 6

Section 4: About You

Which gender do you most identify with?

☐ Male ☐ Female ☐ Other ☐ Prefer not to answer

What is your age?

☐ 18-24 ☐ 25-34 ☐ 35-44 ☐ 45-54 ☐ 55-64 ☐ 65-74 ☐ 75 or older

How would you describe your race/ethnicity? (check all that apply):

☐ American Indian or Alaskan Native ☐ Asian

☐ Black/African American ☐ Caucasian/White

☐ Hispanic/Latino ☐ Other (please specify)_____

☐ Prefer not to answer

What is the highest level of education you have completed?

☐ Secondary or below ☐ Some high school ☐ High school diploma or GED

☐ Some college, or associate degree ☐ Bachelor's/undergraduate degree

☐ Master's degree ☐ Professional degree or doctorate ☐ Other (please specify)_____

What is your annual household income?

☐ Less than $25,000 ☐ $25,000-$34,999 ☐ $35,000-$49,999

☐ $50,000-$74,999 ☐ $75,000-$99,999 ☐ $100,000-$149,999

☐ $150,000-$199,999 ☐ Over $200,000 ☐ Prefer not to answer

What is your marital status?

☐ Single ☐ Married ☐ Widowed

☐ Divorced ☐ Separated

How many children do you have?

☐ None ☐ 1

☐ 2 ☐ 3 ☐ More than 3

How many cars do you have in your household?

☐ None ☐ 1

☐ 2 ☐ More than 2

How would you describe your overall health?

☐ Excellent ☐ Very good

☐ Good ☐ Fair ☐ Poor

Do you have any other comments you would like to share?

_____

_____

_____

Appendix B

State-Level Interviews

COVID Telecommuting Employer Survey

In this interview, we would like to hear your perspective on the flexible working practices before, during and after the COVID-19 pandemic.

Part 1 Basic Information

First of all, please provide information about your experience and role in the industry and in your current company.

Which industry are you currently working in?

How long have you been in this industry?

How many employees are there in your current company?

How long have you been working for your current company?

What is the title of your current position at this company?

Please briefly describe your roles in your current position.

In what city is your workplace located in?

Part 2 Flexible Working Practices

Please describe your company's current policy of flexible working practices (e.g., telework, flexible schedules, etc.). Is the current policy different from the policy pre-COVID-19 pandemic?

Please estimate the percentage of flexible workers and describe their profile (e.g., department, seniority, etc.) in your company.

Describe the success or difficulties of training remotely, improving productivity, maintaining company culture through remote work, or something similar.

Do you expect the policy of flexible working practices to change over the next 12 months? If yes, how so?

Do you expect that COVID-19 variants will affect the policy of flexible working practices?

How have local, state, or federal COVID-19 mandates or direction impacted your company's remote work policies?

Over the next 12 months, do you expect your company to make changes in real estate strategies, such as:

consolidating office locations,

opening more satellite locations,

reducing office space

Over the next 12 months, do you expect that your company will invest in any remote work technology, infrastructure, or services?

Tools for virtual collaboration

IT infrastructure to secure virtual connectivity

Training for managers to manage a more virtual workforce

Conference rooms with enhanced virtual connectivity

Hoteling applications

Communal space in the office

Unassigned (or hoteling) seating in the office

In the future, how will you design workforce development programs that train managers and workers for success when using flexible work practices?

Do you expect to have any changes regarding hiring policy, such as hiring more employees to work remotely from other counties or states?

Overall, do you believe the increase in telecommuting will make your organization more likely to increase or decrease your workforce in the long run? Why?

Bibliography

Alsan, M., Stantcheva, S., Yang, D., & Cutler, D. (2020). Disparities in coronavirus 2019 reported incidence, knowledge, and behavior among US adults. *JAMA network open*, *3*(6), e2012403-e2012403.

Apple (2020) Mobility Trends: Change in routing requests since January 13, 2020. Retrieved from: https://www.apple.com/covid19/mobility

Beck, M. J., & Hensher, D. A. (2020). Insights into the impact of COVID-19 on household travel and activities in Australia – The early days under restrictions. *Transport Policy*, *96*, 76–93. https://doi.org/10.1016/j.tranpol.2020.07.001

Bélanger, F. (1999). Workers' propensity to telecommute: An empirical study. *Information & Management*, *35*(3), 139–153. https://doi.org/10.1016/S0378-7206(98)00091-3

Bentley, F. R., Daskalova, N., & White, B. (2017). Comparing the reliability of Amazon Mechanical Turk and Survey Monkey to traditional market research surveys. *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems*, *May*, 1092–1099.

Berman, J. D., & Ebisu, K. (2020). Changes in U.S. air pollution during the COVID-19 pandemic. *Science of The Total Environment*, *739*, 139864. https://doi.org/10.1016/j.scitotenv.2020.139864

Bieser, J. C. T., Vaddadi, B., Kramers, A., Höjer, M., & Hilty, L. M. (2021). Impacts of telecommuting on time use and travel: A case study of a neighborhood telecommuting center in Stockholm. *Travel Behaviour and Society*, *23*, 157–165. https://doi.org/10.1016/j.tbs.2020.12.001

Bloom, N. (2020). How working from home works out. *Stanford Institute for Economic Policy Research*, 8.

Brynjolfsson, E., Horton, J. J., Ozimek, A., Rock, D., Sharma, G., & TuYe, H. Y. (2020). *COVID-19 and remote work: An early look at US data* (No. w27344). National Bureau of Economic Research.

Budnitz, H., Chapman, L., & Tranos, E. (2018). Better by bus? Insights into public transport travel behaviour during Storm *Doris* in Reading, UK. *Weather*, *73*(2), 54–60. https://doi.org/10.1002/wea.3058

Budnitz, H., Tranos, E., & Chapman, L. (2020). Telecommuting and other trips: An English case study. *Journal of Transport Geography*, *85*, 102713. https://doi.org/10.1016/j.jtrangeo.2020.102713

Bursztyn, L., Rao, A., Roth, C. P., & Yanagizawa-Drott, D. H. (2020). *Misinformation during a pandemic* (No. w27417). National Bureau of Economic Research.

Caulfield, B. (2015). Does it pay to work from home? Examining the factors influencing working from home in the Greater Dublin Area. *Case Studies on Transport Policy*, *3*(2), 206–214. https://doi.org/10.1016/j.cstp.2015.04.004

De Abreu e Silva, J., & Melo, P. C. (2018). Home telework, travel behavior, and land-use patterns: A path analysis of British single-worker households. *Journal of Transport and Land Use*, *11*(1). https://doi.org/10.5198/jtlu.2018.1134

de Haas, M., Faber, R., & Hamersma, M. (2020). How COVID-19 and the Dutch 'intelligent lockdown' change activities, work and travel behaviour: Evidence from longitudinal data in the Netherlands. *Transportation Research Interdisciplinary Perspectives*, *6*, 100150. https://doi.org/10.1016/j.trip.2020.100150

DeSilver, D. (2020) Before the coronavirus, telework was an optional benefit, mostly for the affluent few, *Pew Research Center*, [Online] 20th March. Available from: https://www.pewresearch.org/fact-tank/2020/03/20/before-the-coronavirus-telework-was-an-optional-benefit-mostly-for-the-affluent-few/

US Bureau of Labor Statistics. (2020). Ability to Work from Home: Evidence from Two Surveys and Implications for the Labor Market in the COVID-19 Pandemic. *Monthly Labor Review*. Retrieved from: https://doi.org/10.21916/mlr.2020.14

Dingel, J. I., & Neiman, B. (2020). How many jobs can be done at home? *Journal of Public Economics*, *189*, 104235. https://doi.org/10.1016/j.jpubeco.2020.104235

Dissanayake, D., & Morikawa, T. (2008). Impact assessment of satellite centre-based telecommuting on travel and air quality in developing countries by exploring the link between travel behaviour and urban form. *Transportation Research Part A: Policy and Practice*, *42*(6), 883–894. https://doi.org/10.1016/j.tra.2007.12.006

Drucker, J., & Khattak, A. J. (2000). Propensity to Work from Home: Modeling Results from the 1995 Nationwide Personal Transportation Survey. *Transportation Research Record: Journal of the Transportation Research Board*, *1706*(1), 108–117. https://doi.org/10.3141/1706-13

Eom, S.-J., Choi, N., & Sung, W. (2016). The use of smart work in government: Empirical analysis of Korean experiences. *Government Information Quarterly*, *33*(3), 562–571. https://doi.org/10.1016/j.giq.2016.01.005

Ettema, D. (2010). The impact of telecommuting on residential relocation and residential preferences: A latent class modelling approach. *Journal of Transport and Land Use*, *3*(1). https://doi.org/10.5198/jtlu.v3i1.61

Global Workplace Analytics. (2019) "Advantages of Agile Work Strategies for Companies". Retrieved from: http://globalworkplaceanalytics.com/resources

Global Workplace Analytics. (2019) "The Bottom Line on Telework for the Thurston Region State and Local Government". Retrieved from: http://globalworkplaceanalytics.com/resources

Gordon, C. E. (2015). Flexible Workplace Practices: Employees' Experiences in Small IT Firms. *Relations Industrielles*, *69*(4), 766–784. https://doi.org/10.7202/1028111ar

Google (2020). COVID-19 Community Mobility Reports. Retrieved from https://www.gstatic.com/covid19/mobility/2021-01-15_US_California_Mobility_Report_en.pdf

Handy, S. L., & Mokhtarian, P. L. (1995). Planning for telecommuting measurement and policy issues. *Journal of the American Planning Association*, *61*(1), 99-111.

Handy, S. L., & Mokhtarian, P. L. (1996). Forecasting telecommuting. *Transportation*, *23*(2), 163-190.

Kannan, S., Miller, C., Greene, S. and colleagues (2021) Los Angeles Times California Coronavirus Data. Retrieved from https://github.com/datadesk/california-coronavirus-data

Kees, J., Berry, C., Burton, S., & Sheehan, K. (2017). An Analysis of Data Quality: Professional Panels, Student Subject Pools, and Amazon's Mechanical Turk. *Journal of Advertising*, *46*(1), 141–155. http://doi.org/10.1080/00913367.2016.1269304

Loo, B. P. Y., & Wang, B. (2018). Factors associated with home-based e-working and e-shopping in Nanjing, China. *Transportation*, *45*(2), 365–384. https://doi.org/10.1007/s11116-017-9792-0

Mahler, J. (2012). The Telework Divide: Managerial and Personnel Challenges of Telework. *Review of Public Personnel Administration*, *32*(4), 407–418. https://doi.org/10.1177/0734371X12458127

Makridis, C., & Rothwell, J. T. (2020). The real cost of political polarization: Evidence from the COVID-19 pandemic. *Available at SSRN 3638373*.

Mannering, J. S., & Mokhtarian, P. L. (1995). Modeling the choice of telecommuting frequency in California: An exploratory analysis. *Technological Forecasting and Social Change*, *49*(1), 49–73. https://doi.org/10.1016/0040-1625(95)00005-U

Martínez, J., Prager, F., and J. Brodmann (2020) *South Bay Economic Forecast Report 2020-21*. CSU Dominguez Hills South Bay Economics Institute. Retrieved from https://www.csudh.edu/Assets/csudh-sites/uce/docs/forecast/CSUDH_South-Bay-Economic-Forecast-Report_2020.pdf

Mokhtarian, P. L. (2004). A conceptual analysis of the transportation impacts of B2C e-commerce. *Transportation*, *31*(3), 257–284. https://doi.org/10.1023/B:PORT.0000025428.64128.d3

Mokhtarian, P. L., & Varma, K. V. (1998). The trade-off between trips and distance traveled in analyzing the emissions impacts of center-based telecommuting. *Transportation Research Part D: Transport and Environment*, *3*(6), 419–428. https://doi.org/10.1016/S1361-9209(98)00018-2

Mokhtarian, P. L. (1997). The transportation impacts of telecommuting: recent empirical findings. *Understanding travel behaviour in an era of change*.

NCHRP, National Cooperative Highway Research Program, Transportation Research Board, & National Academies of Sciences, Engineering, and Medicine. (2019). *Foreseeing the Impact of Transformational Technologies on Land Use and Transportation* (p. 25580). Transportation Research Board. https://doi.org/10.17226/25580

Organization for Economic Cooperation and Development (OECD). (2020). Productivity gains from teleworking in the post COVID-19 era: How can public policies make it happen?

Peer, E., Vosgerau, J., & Acquisti, A. (2014). Reputation as a sufficient condition for data quality on Amazon Mechanical Turk. *Behavior Research Methods*, *46*, 1023–1031. http://doi.org/10.3758/s13428-013-0434-y

Pérez Pérez, M., Martínez Sánchez, A. M., & de Luis Carnicer, M. P. (2003). The organizational implications of human resources managers' perception of teleworking. *Personnel Review*.

Peters, P., Tijdens, K. G., & Wetzels, C. (2004). Employees' opportunities, preferences, and practices in telecommuting adoption. *Information & Management*, *41*(4), 469–482. https://doi.org/10.1016/S0378-7206(03)00085-5

Popuri, Y. D., & Bhat, C. R. (2003). On Modeling Choice and Frequency of Home-Based Telecommuting. *Transportation Research Record: Journal of the Transportation Research Board*, *1858*(1), 55–60. https://doi.org/10.3141/1858-08

Prager, F., Rhoads, M., Martinez, J. N., Cagle, C., Baum, A., & Bacharach, J. (2019). The "GO-Virtual Initiative": Using Flexible Workplace Practices to Reduce Traffic Congestion, Increase Economic Development, and Provide More Access to Affordable Housing Choices in the South Bay Region of Los Angeles County. 125.

Prager, F., Rhoads, M., & Martinez, J. N. (2022). The COVID-19 economic shutdown and the future of flexible workplace practices in the South Bay region of Los Angeles County. *Transport Policy*.

Rhoads, M. (2015). *The Flexible Workplace: Regional Tendencies and Daily Travel Implications*. (Doctoral dissertation). Los Angeles: University of Southern California Libraries. Retrieved from: http://digitallibrary.usc.edu/cdm/ref/collection/p15799coll3/id/528426

Sarbu, M. (2015). Determinants of work-at-home arrangements for German employees. *Labour*, *29*(4), 444-469.

Sener, I. N., & Bhat, C. R. (2011). A Copula-Based Sample Selection Model of Telecommuting Choice and Frequency. *Environment and Planning A: Economy and Space*, *43*(1), 126–145. https://doi.org/10.1068/a43133

Shabanpour, R., Golshani, N., Tayarani, M., Auld, J., & Mohammadian, A. (Kouros). (2018). Analysis of telecommuting behavior and impacts on travel demand and the environment. *Transportation Research Part D: Transport and Environment*, *62*, 563–576. https://doi.org/10.1016/j.trd.2018.04.003

Shilling, F. (2020). Special Report 3: Impact of COVID19 Mitigation on Traffic, Fuel Use and Climate Change. Retrieved from: https://trid.trb.org/view/1704059

Southern California Association of Governments (2020). Snapshot of COVID-19 Transportation Impacts in the SCAG region. Retrieved from: https://scag.ca.gov/post/snapshot-covid-19-transportation-impacts-scag-region

U.S. Bureau of Labor Statistics (2021). "24 percent of employed people did some or all of their work at home in 2015 on the Internet". *The Economics Daily*. Retrieved from: https://www.bls.gov/opub/ted/2016/24-percent-of-employed-people-did-some-or-all-of-their-work-at-home-in-2015.htm

U.S. Bureau of Transportation Statistics (2021). COVID-19 Related Transportation Statistics. Retrieved from: https://www.bts.gov/covid-19

Walls, M., Safirova, E., & Jiang, Y. (2007). What Drives Telecommuting? Relative Impact of Worker Demographics, Employer Characteristics, and Job Types. *Transportation Research Record: Journal of the Transportation Research Board*, *2010*(1), 111–120. https://doi.org/10.3141/2010-13

Wooldridge, J. M. (2001). Econometric analysis of cross section and panel data, MIT press. Cambridge, MA.

Zhu, P. (2012). Are telecommuting and personal travel complements or substitutes? *The Annals of Regional Science*, *48*(2), 619–639. https://doi.org/10.1007/s00168-011-0460-6

Zhu, P. (2013). Telecommuting, Household Commute and Location Choice. *Urban Studies*, *50*(12), 2441–2459. https://doi.org/10.1177/0042098012474520

Zhu, P., & Mason, S. G. (2014). The impact of telecommuting on personal vehicle usage and environmental sustainability. *International Journal of Environmental Science and Technology*, *11*(8), 2185-2200

About the Authors

Tianjun Lu

Dr. Tianjun Lu is an Assistant Professor in the Department of Earth Science and Geography at California State University, Dominguez Hills. He received his Ph.D. in Planning, Governance, and Globalization from Virginia Tech and was a Research Scientist at the University of Washington. Dr. Lu's has published multiple papers in Transportation Research Part D: Transport and Environment, Environmental Science and Technology, and Science of the Total Environment. His scholarly contribution mainly falls into multidisciplinary fields including transportation planning, air pollution exposure assessment, data analytics, and community engagement. Dr. Lu has rich experience in developing nationwide air quality models funded by the US Environmental Protection Agency (i.e., air pollution exposure models in the continental US), community-level air quality project funded by the Minneapolis Department of Health, MN and CSUDH, and community-level field measurements and modeling work funded by US Department of Transportation. Dr. Lu is the principal Investigator on this project.

Jian-yu (Fisher) Ke

Dr. Jian-yu Ke is an Associate Professor in the Department of Information Systems & Operations Management at California State University, Dominguez Hills. He received his Ph.D. in Supply Chain Management from the University of Maryland and was a fellow at Massachusetts Institute of Technology. Dr. Ke's recent works were published by Production and Operations Management (listed in Financial Times Top 50 Journals), Journal of Business Research, International Journal of Physical Distribution and Logistics Management, and Journal of Purchasing and Supply Management. Dr. Ke has 14 research publications during 2011-2022 and his research interests include global transportation strategies, global supply chain management, manufacturing strategies, and the alignment of supply chain strategy with industry characteristics. Dr. Ke was the principal investigator on a California state-funded project named "Achieving Excellence for California's Freight System: Developing Competitiveness and Performance Metrics Incorporating Sustainability, Resilience, and Workforce Development."

Fynnwin Prager

Dr. Prager is an Associate Professor of Public Administration at California State University, Dominguez Hills, where he is Co-Director of the South Bay Economics Institute. Dr. Prager received his Ph.D. in Policy, Planning and Development from the University of Southern California, and undertook a post-doctoral appointment at the Center for Risk and Economic Analysis of Terrorism Events. With CSUTC, Dr. Prager served as PI for the "GO-Virtual Initiative," which explores flexible workplace practices for traffic congestion reduction, economic development improvement, and various affordable housing choices in the Los Angeles area, and currently participates in a project related to California's freight system competitiveness as a Co-PI.

Dr. Prager's relevant academic experiences include writing a Ph.D. dissertation on climate policy and emissions mitigation; publishing studies related to transportation systems and disasters, receiving the METRANS student of the year award; participation as regular reviewer and editorial board member of Transportation Review Part E; and experience of conducting surveys and a pilot evaluation study of major US CBP trade initiative.

Jose N. Martinez

Dr. Martinez is an Associate Professor of Economics and Chair of the Accounting, Finance, and Economics department at California State University, Dominguez Hills. He received his Ph.D. and Master's degree in Economics from University of California San Diego. Some of his latest research focus on the use of remittances from Mexican migrants living in the U.S., the spatial contagion effects of crime at municipality level in Mexico, the economic impact of foreign-owned enterprises in Southern California, and the impact of economic uncertainty on stock markets in Latin America. As Co-PI, he has participated in multiple SB1 projects, including "GO-Virtual Initiative," which uses flexible workplace practices to reduce traffic congestion and increase economic development in the South Bay Region of Los Angeles County, and California's freight system competitiveness. His expertise focuses on labor economics, applied economics, and time series modeling.

MTI FOUNDER

Hon. Norman Y. Mineta

MTI BOARD OF TRUSTEES

Directors

MINETA TRANSPORTATION INSTITUTE