WORKING AT HOME AND ELSEWHERE IN THE CITY: MOBILE CLOUD COMPUTING, TELEWORK, AND URBAN TRAVEL

by

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ABSTRACT OF THE DISSERTATION

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In this dissertation I explore the relationship of mobile cloud computing with transportation planning and travel behavior through two related research questions. My first research question asks: *how has planning practice, in relation to technological change, sought to mediate individual work location practices in the United States?* I address this question through historical analyses and literature review, showing how work location has been an interest of planning practice in the United States since its inception, by way of zoning, land use transport modeling, and telework. I frame the history of "telecommuting" advocacy in the United States as a case of strategic niche management, which supported a limited reconfiguration of work location practices. Finally I consider the representation of telework through three phases of computing infrastructure: centralized computing, personal computing, and mobile cloud computing. My second research question asks: *how does the adoption of mobile cloud computing affect work location decision making and travel outcomes among workers in a multimodal metropolitan regional context?* I address this question with primary and secondary empirical data, including an analysis of American Time Use Survey data, and an original

survey and set of interviews conducted in the New York Metropolitan area. Findings at the national level show that teleworking from home is growing in the United States since 2003 and is associated with reduced overall travel time and reduced likelihood of participation in peak hour travel. Primary interview research shows how computing infrastructure is part of the context of telework decision-making, and that under mobile cloud computing, workers use platforms for team collaboration, formal policies give way to informal flexibility, and workers choose location based on tasks at hand. Primary survey research shows that the use of mobile cloud computing platforms is associated with reasons for telework that represent greater personal autonomy. In the conclusion of this dissertation I point to a practical application of findings for informing incentive-based approaches to managing travel demand, and argue that computing infrastructure is an increasingly fundamental part of the scientific and technical knowledge that planners must relate to the public domain, creating both challenges and opportunities for the discipline.

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Chapter 1: Introduction

My interest in the relationship of work location with information and communication technology dates back to a pre-academic career in Internet website development. I broke into that industry in the 1990s when I created the first website for Oren's Daily Roast, a coffee roasting chain in what was then a mostly pre-Starbucks New York City. After a shift making espresso drinks behind the counter at one of their stores I traveled uptown to the main office and pitched to Oren, the idea of creating a website to sell coffee beans through the "world wide web." I designed and built that website on my personal computer—as a freelancer working from a makeshift home office. I had taught myself to code HTML on the same personal computer just a year earlier. I eventually leveraged my experience with Oren's website to secure a full-time web developer job at a publishing industry startup called Bookwire. Work location played out differently for me at Bookwire. In addition to being required to be present in the office 9 to 5 every day, I was designated for a period to be the employee connected 24/7 to our web server through a beeper alert system. At the time, our website was served to the Internet entirely out of our small Manhattan office running on a Macintosh desktop computer. When the server crashed outside of business hours, unless it was the very middle of the night, I would have to travel to the office, and push a button to restart it. Rather than granting me greater flexibility to choose where to conduct work, this particular technological configuration made demands of my location at inconvenient times.

A few years later I found myself at an advertising technology firm as a software engineer, and encountered a three-letter acronym that made my interest in the issue of

work location explicit. On any given day at Quigo Technologies, depending on the weather and state of the New York City transportation system, one or more of the software team members would send out an email, devoid of body and with the subject reading only:

"WFH"

These letters, of course, indicated that they would be "Working From Home" for the day. There were two aspects of our information and communication technology-supported work processes, to my mind at the time, which supported this type of flexibility of work location among the engineers at Quigo. Firstly, all of our team's work on the large Internet software application that we supported was managed through an installation of Bugzilla, an open source bug and feature-tracking tool. Each day I would open up our Bugzilla interface in a web browser to see which tasks I should prioritize. I could do that just as easily from home as from the office because it was made accessible through the Internet. My manager and colleagues could also check my progress and prioritize new tasks through Bugzilla, also from any location or computer. Secondly, our team communicated through instant messaging (IM), and we were expected to have that system on and to be reachable when working from home. Since we would often use IM to communicate in the office, where we were a mere 10 feet from one another, adding a few miles of physical distance didn't seem to matter. It worked well and I used my spatial flexibility to avoid bad weather and peak-hour travel and to gain focus on complex problems.

A few years later, I worked as the Director of Technology at an international education nonprofit organization called Pencils of Promise. I joined when the startup

organization could barely fit into a 15-by-15 foot concrete box office on New York City's lower east side, and remained through their barely fitting into a floor-through office in New York City's flower district. Both offices had open plans and were full of school-age interns. As I sometimes needed quiet to focus on writing code or configuring a piece of software I asserted the option to work from home on select days. Meetings would usually get me into the office, as I didn't—and still do not—like joining them remotely when most participants are present. Another part of my job consisted of setting up and advocating for the internal use of the Salesforce.com platform for tracking internal data, related to both fundraising and education projects. It was my first time working with an explicitly "cloud-based" software platform, although I soon came to see the similarities to my previous company's use of the Bugzilla and instant messaging. It was also an education for me because of the challenge of getting colleagues to switch from using Excel and adopt a new way of working. After team leaders in the organization embraced Salesforce.com, its benefits began to be felt as records could be accessed by employees all over the world, at work, at home, and on the go across multiple devices, and after I had departed, the organization presented their work at the Salesforce.com annual conference as an example for other nonprofits to emulate.

Academics, especially those who teach as adjuncts at multiple universities as I now do, can be nomadic in their work location practices. My laptop computer is the center of my working world now, and my students access and submit assignments through a course website. This dissertation was written from a variety of locations on that laptop, and none of them fit the description of a traditional office. There is my home office, which is located in a bedroom. It was a good place for conducting interviews by

Skype and for writing about complex topics, although a next-door building construction project created challenges. A few feet away from the desk, my bed itself—from where I type these very words—was an important location for writing, especially in the early morning hours, which for me are among the most productive. Then there are the cafés in my neighborhood, which are usually full of workers with laptops, and the local coworking space that offers an affordable daily rate of ten dollars to work at communal tables and drink complimentary coffee. On days when I work from home I walk everywhere, which is in stark contrast to my teaching days on which I hurtle through the air in a metal-plastic box of one sort or another to get to the classroom. The train is a preferable option to my car because—like bed in the early morning—I find it productive space for writing.

It doesn't take a trained social scientist to know that my personal experiences with work location as a barista, web developer, software engineer, nonprofit director of technology, and adjunct college instructor don't provide a full picture of the relationship between information and communication technology and work location in the United States. I have never worked in sales, and certainly the many jobs that cannot be done remotely due to their physicality raise the question of whether work location flexibility represents a new form of inequality. But my own experiences did—in a slow, simmering way—pique an interest in this topic that developed through an exploration of planning, travel behavior, and technology studies literatures that I undertook as part of my PhD degree. Furthermore the intellectual and practical histories that I encountered within this topic captured my imagination, with notions of "telecommuting" workers, the "electronic cottage", and a "death of distance," Not that I shared the optimism of these ideas, but

rather that I thought their very existence as concepts forged by human efforts formed part of an important story about the relationship of technology and society. It is a relationship that is at the heart of the discipline of planning whose aim, broadly defined, is to "relate scientific and technical knowledge to actions in the public domain" (Friedmann 1987). I also wanted to contribute to conversations regarding the theoretical frameworks that give some understanding of the complex relationship between information and communication technology and travel, such as about space-time constraints, activity fragmentation, and nomadic work. Finally this topic has connections to efforts to confront society's most pressing and complex challenges, such as the need to achieve sustainable resource usage in the face of climate change, and issues of inequality contributing to political instability.

The central empirical research question of this dissertation is: *How does the adoption of mobile cloud computing platforms affect work location decision making and travel outcomes among workers in a multimodal metropolitan regional context?* However in seeking to strongly connect findings for this question—which are based on interview and survey research—to planning practice, I first address an equally important historical research question through historical analyses: *How has planning and policymaking, in relation to technological change, mediated individual work location practices in the United States?* Only in addressing both of these research questions—the present empirical and the historical—can I draw conclusions about mobile cloud computing that have utility for the discipline of planning in addressing challenges of sustainability and public health.

Following this introductory chapter, **Chapter 2**, "Home Away From Work: The Distinction Between Home and Workplace in Planning Before 1970" considers the role

of early planning practice in promoting a separation of home and work through zoning and related ordinances, finding it in part a reaction to perceptions of home-based work in tenement districts. It shows how this distinction became later embedded in the early methods of land use and transportation planning. Over the time period covered by this chapter, the separation between home and work had shifted from being one desired outcome of planning, to being a premise of planning as the discipline confronted problems of traffic.

Chapter 3, "A Long Groundwork for Reconfiguration: Telecommuting Advocacy in the United States as a Case of Strategic Niche Management" picks up this thread in the 1970s, with the introduction of the concept of "telecommuting" by a team of researchers in Los Angeles, California to confront challenges related to traffic (Nilles et al 1976). Through an historical analysis and review of literature, it shows how from this beginning through the 1990s, telecommuting advocacy represents a case of *strategic niche management*, a practice in which innovations are managed over the long term toward a societal benefit (Kemp et al. 1998). While these efforts of advocates contributed to a reconfiguration of work location practices in the workplace, due to a weakening of telecommuting's original vision, its sustainability benefits are now unclear, and the ultimate outcome depends on factors beyond the control of its advocates.

Chapter 4 "Telework and Computing Infrastructure: An Historical Perspective Across Centralized, Personal, and Mobile Cloud Computing" considers telework against three phases of computing infrastructure. *Centralized computing* refers to mainframe computer systems accessed by authorized employees through computer terminals, as well as early single purpose standalone workstations, including word processors that would

have been managed centrally within organizations. The earliest practices of telework through computer systems developed under centralized computing. *Personal computing* refers to fully standalone desktop and portable computers designed to serve a variety of functions for a single user. Under personal computing, the home was reframed as a space of self-entrepreneurship, which for firms raised questions about trust and the ownership and control of equipment used for teleworking. Portable personal computing highlighted the technical challenges of uneven access to networks and work materials across computing contexts. *Mobile cloud computing* refers to the provision of data and processing by distributed systems and accessed by the user through various devices and contexts. Mobile cloud computing, seen through the example of email, supported solutions to the technical problems highlighted by portable personal computing, but contributed to perceptions of challenges of work life balance.

Chapter 5 "Work Location and Travel in the United States 2003-2017: An Analysis of American Time Use Survey Data" begins the empirical portion of the dissertation by exploring the relationship between work location and travel among US workers based on national survey data. Trends over the 14-year period show that instances of working from home and working from vehicles are increasing. There is a significant relationship between telework and peak hour travel demand, however morning peaks are more strongly affected than evening peaks. An analysis of departure times shows part-day homeworkers who conduct work in the morning, and full-day homeworkers both shift their departure times to later times within or after peak travel hours. Finally only full-day telecommuting is associated with less total daily travel time,

as opposed to part-day telecommuting where a worker also visits the office on the day they work from home.

Chapter 6 "Remote Work in the New York Metropolitan Area Interview Results: Mobile Cloud Computing and Work Location Decision-Making" present the first half of results from an original empirical study. Based on 31 semi-structured interviews with workers in the New York Metropolitan Area who conduct some or all of their work remotely with a computer and/or smartphone it offers an inductive model of work location decision-making. Four contextual factors set the stage for day-of decision-making: computing infrastructure, attitude towards commute and time spent commuting, understanding of the allowance of remote work, and perceptions of productivity and distraction. These contextual factors inform the specific factors that come into play on or around the day-of decision, which include errands and chores, parenting, weather, illness, congestion, vacation, and a desire for a change of scene. Interviews showed the team collaboration platforms, enabled by mobile cloud computing were a part of the context of interviewee's work location decision-making

Chapter 7 "Remote Work in the New York Metropolitan Area Survey Results: Mobile Cloud Computing and the Loosening of Spatial Constraints Towards Personal Autonomy" presents the second half of results from an original empirical study. Based on data collected from a survey of 185 remote workers in the New York City Metropolitan Area it tests the effects of an individual's use of mobile cloud computing software platforms—such as those allowing messaging, document sharing, and video conferencing across devices and locations—on reasons for the decision to telework from home. It finds that the more engaged workers are with mobile cloud software platforms, the more

importance they give to reasons for working from home that represent greater personal autonomy, such as reducing stress or easing commuting, compared to more compulsory reasons for teleworking such as having excess work or parenting. These findings support past research on how ICTs can loosen spatial constraints related to work, while highlighting the particular role of mobile cloud software platforms in doing so and the nature of its effects.

Chapter 8 revisits this dissertation's original research questions—the historical and the empirical—as it considers what mobile cloud computing implies for planning practice broadly, and for transportation planning in particular. It outlines six key findings and points to a potential practical application for informing incentive-based approaches to managing travel demand. Finally it argues that computing infrastructure—representing the ways that processing power is integrated within organizations and accessed by individuals—is an increasingly fundamental part of the scientific and technical knowledge that planners must relate to the public domain, creating both challenges and opportunities for the discipline as it addresses mounting challenges of inequality and sustainability.

Chapter 2: Home Away From Work: The Distinction Between Home and Workplace in Planning Before 1970

The locations in which individuals conduct work for their occupation has been an interest of planning in the United States since its origins. In this chapter I show that during the first half of the 20th century, the distinction between home and workplace grew from being one desired *outcome* of planning to being a *premise* of planning. In its early decades, zoning and related ordinances reinforced and distributed the distinction between workplace and home to create stable residential districts that conformed to notions of a healthy environment for family life, in part a reaction to representations of home-based work and manufacturing in tenements. The home/work dichotomy logically became embedded in the influential methodologies of early land use-transport modeling as it tried to reckon with problems of traffic, yet this use was influenced by earlier periods of planning.

Planning scholars have described the origins of the tendency of American planning towards single-use districts. Sonia Hirt (2013) considers how a stricter separation of home from other uses differentiated American planning from its European counterparts. Emily Talen (2012) considers how early ideas of zoning actually embraced a greater diversity of uses than its practices later came to allow in practice. This chapter will revisit these interests, but with an eye towards how these tendencies subsequently manifested in the early methodologies of land use transport modeling. I combines an historical analysis of primary sources with a review of planning literature to build its theoretical contribution, through a recounting of planning practice and theory around the distinctions of home and workplace through 1970. Firstly I consider the functions and

representation of home-based work in the first decades of the 20th century. Secondly I examine how zoning and other ordinances sought to separate residential uses—particularly single-family homes—from other uses. Thirdly I review the development of early methodologies in transportation planning, with attention to how notions of the separation of uses became uncritically embedded in these methodologies. The chapter ends at the dawn of a decade that would see a critique of large-scale regional modeling, and the growth of interest in mixed-use development, as well as the birth of the notion of telecommuting.

i. Home-based Work in US Cities at the Turn of the 19th Century

The presence of home-based piece-work and manufacturing, as well as the close physical proximity of factories and dwellings in urban tenement areas, was a topic of concern in the years surrounding the start of the twentieth century. Calls for tenement reform from charitable movements and activists pointed to unhealthy conditions, the exploitative nature of work relationships, and the impacts of environment on children being raised in tenements. This discourse about negative outcomes from a mingling of work and home in mixed use and multifamily urban areas, provided an influential recent history for the very earliest efforts at zoning.

Prior to industrialization, home-based work existed in rural settings, but represented a step towards both urbanization and industrialization. In Britain "cottage" industry came to refer to income-generating work done by tenant farmers and landless tenants in their homes, particular in winter months when agricultural work was scarce. Growth in cottage textile manufacturing during the late 15th century was driven by the "enclosure" of arable land for pasture use; and this cottage production connected to urban

centers through its management by merchant capitalists, whose members might own some of the machinery even if located in the cottager's home (Polanyi 1944). The production skills of the cottagers along with their disconnection from the land through enclosure, helped set the stage for the industrial revolution, which shifted the location of labor from the rural cottage to the more urban factory (Polanyi 1944). While physically isolated, cottagers became connected to the urban centers where most relocated after the appearance of factory centers in the industrial revolution.

But home based-work practices also emerged in new urban centers, and became a problem in large US cities at the end of the 19th and start of the 20th centuries. Electric streetcars were the primary urban movers of people in these decades, opening up new areas for development away from the crowded cores of large US cities. Major private investment in new and updated electric streetcar systems occurred from 1887 through 1907, with 1902 being the peak year of financial return on those investments (Jones 2008). The electric streetcar enabled people of even moderate means to move further afield into the expanding new suburban areas of US cities, partly due to a policy of low-rate fares and free transfers (Jackson 1985). In bringing new land to the market streetcars made possible the separation of home from the busy downtown, and gave a means to traverse the distance in between (Warner 1978). Yet this new distinction between home and workplace was not clear or available for many lower-income residents at this time, particularly newly arrived immigrants to American cities, women, and children.

For recent immigrants in crowded tenement districts, earning money though some kind of home-based work, such as tailoring was an easy way to begin or supplement earning in a new place using known skills. Jacob Riis, in his influential book *How the*

Other Half Lives (1890), documents two types of manufacturing in tenement neighborhoods: "sweating" (the manufacture of clothing) among Russian Jewish communities on New York's Lower East Side, and cigar making among Bohemian residents in upper Manhattan. Such small tenement factories emerged as recent immigrants hired on others to work alongside them in their home, some eventually upgrading larger spaces accommodating more workers in the growing enterprise (Newmeyer 1904). Riis documents, both verbally and visually, in striking photographs, a crowded "tenement factory" in which a family manufactures knee-pants in their home, while still letting out six of their ten sewing machines to other workers (Riis 1890). The National Consumers League in 1912 joked that in the New York tenements "everything but nitro-glycerin and gunpowder may be manufactured" ("Woman Urges Abolition" 1912).

The conditions of much tenement manufacturing were grim and the hours extreme. Rather than filling in for scarce work during the off-seasons, as did the original cottage industries in England, US urban home-based work took advantage of excess immigrant labor to continue production on nights, weekends, and in physical spaces beyond the walls of textile factories. For example some parts of the production process were subcontracted out from larger formal factories, with items such as coats being finished by a home-based worker even as she cares for children in a practice called by critics the "cradling system" ("Ready Made Clothing No Longer Menace to Health" 1909). One crowded "tenement factory" in which a family manufactured knee-pants in their home, leased six of their ten sewing machines to other workers (Riis 1890). A New York State report on factory work conditions is filled with accounts of home-based

manufacture, including garment factories run out of the rear of homes in Rochester, home-based cigar manufacture in Buffalo, and several cases of female workers who tailor clothes in factories during the day and finish the garments at home at night (State of New York, 1912).

Opposition to the conditions in tenement houses in part stemmed from concerns about health conditions inside that were related to work practices, including child labor. Boston's Anti-Tenement House League was formed with the purpose of "calling attention to this new slavery" of tenement house sweating. Their 1894 report opens with a placard depicting a room of workers at sewing machines captioned "where six children died" (The Anti-Tenement House League, 1894). The effect of tenement environments—in particular the absence of what was considered to be a proper home—was argued by Col. Thomas Knox among many others to be connected to problems of crime:

> *The young criminal is the product almost exclusively of these training houses of vice and crime in the worst tenement house districts... Eighty percent of the crimes committed in New York City against property and against the person are perpetrated by individuals who never had any home-life.* (Knox n.d.)

Charity organizations and mission houses sought to improve conditions in tenements by engaging with residents and providing services within tenement areas. Private charity organizations such as the longstanding Children's Aid Society, and the Association for Improving the Condition of the Poor provided aid in exchange for work and instruction. Missions also provided support in visiting and living among the tenement poor, finding them a fertile ground for recruitment: one missionary defending their inner community

life, touted tenements as “a means of promoting the brotherhood of man and the union of Christendom” (Elsing 1892).

Unions were active in ferreting out home-based work practices. Union representatives were prominent in the list of witnesses giving evidence on home-based work practices to the New York State Legislature (State of New York, 1912). For textile manufacture, a host of labor organizations including the Cloakmakers Union, and United Garment Workers of America, and Ladies Garment Worker’s Union were involved in advocating for regulations and better conditions in sweatshops. The latter was especially active in raising questions about the subcontracting system through which much home-based textiles work was arranged (“Gertrude Barnum Pleads Cause of Garment Strikers” 1913).

Home-based work was not prominent in all tenement areas. A 1904 survey of two tenement sections in the city of Buffalo that were home to over two thousand apartments noted just nine manufacturing sites, also finding that a majority of heads of households in those areas had outside employment as laborers. Nor had it always been present even in the New York City neighborhoods that became most strongly associated with it. An 1857 state report on the conditions in the tenement houses noted some presence of income-generating activities such as sewing and washing, but mentioned no large scale manufacturing while still largely dismissing the lifestyle of tenement dwellers as consisting largely of “beggary, imposture, theft, and licentiousness.”

Yet despite their uneven distribution, and perhaps due to their recent appearance, so called “sweatshops” were a topic of great popular concern during the first decade of the century, especially as they affected women and children, and were featured heavily in

newspaper accounts in large cities like New York City and Chicago. In Chicago men accounted for just 5000 of more than 25,000 sweatshop workers in tenement districts, with the rest being women or children (Kirkland 1892). Laura Hapke (2004), in tracing representations of sweatshops throughout US history, argues that the term "sweatshop" imperfectly represented a complex and varied mixing of domestic life and labor, a world in which women occupied unfamiliar and unacceptable roles in the eyes of much of the public.

Women's participation in the labor force at the time was limited by social convention. While higher-income women could afford to not participate, women from lower income and immigrant families were forced to contend with the daunting challenge of seeking work in this limited landscape, which included opportunities to conduct work at home and working in tenement manufacturing. Yet even in the face of this need, their effort to earn was criticized on the grounds that the agency it granted led to immoral behavior. A charity worker at the East Side Settlement House considered these income-earning women as turning their backs on motherhood and homemaking as they explored interests in the latest fashions and dances.

"The two perils which especially confront the working girl just now have been born of the dress and of the dancing she has copied from the girls who do not have to work…The factory girl, the girl clerk in the big store is taught nothing of good motherhood by work at the machine or counter." ("New York's Biggest Problem" 1912) The alternative promoted by social reformers was for women to be taught domestic skills in order to be better keepers of the home. For example, The Hartley House mission, founded in Manhattan's West side in 1897, gave women instruction in home cooking and

sewing, while also providing them with occasional food aid in exchange for a day's labor, such as quilting and cleaning (Stokes 1897).

Women both in and out of tenements district were seeking opportunities to earn, which made them susceptible to scam "work from home" classified advertisements. In a 1905 case, multiple women provided a cash deposit to the "Wilson Sign Company" for the materials to produce cardboard signs at home with the promise of being paid for their work, but none of their produced signs were ever accepted by the company and the deposit was never refunded. With limited opportunities for workplace work, women were forced to be creative. The *Chicago Tribune* ran an earnest 1913 series of articles for women entitled "How you can earn money working at home", listing such ideas as "mending old clothes", "selling flowers", and making "lunches for workers" ("How You Can Earn Money" 1913).

Home-based work in tenements was problematized as being unhealthy, exploitative, and immoral in US cities just as transportation technologies were opening up new areas for development some distance from the crowded downtown cores of cities. Yet regulations that sought to improve tenements did not confront issues of the permissible uses of dwelling units. For example, New York City's Tenement House Law did not curb or regulate work activities within tenements except for prostitution and a few occupations considered to be fire hazards including backing, fat boiling, and any business involving combustible materials ("Building and Health Laws" 1911). It was rather zoning, which arose out of this period of tenement reform that sought to regulate and define the appropriate locations of types of activities.

ii. Regulating the Separation of Home and Work Through Zoning

The course of zoning in the United States before 1970, and the ultimate legal victory of exclusionary zoning, contributed to the distinction between workplace and home in three ways. Firstly exclusive residential districts, by their definition, prevented new employment-generating commercial and industrial enterprises from locating within defined geographic areas. Secondly, zoning tended to permit only retail clusters in areas near to residential districts, keeping larger "central" commercial zones at greater distance confined to the urban core. Thirdly, the exclusion of multifamily housing eliminated what had been perceived as less-regulated spaces where work and home could coexist within the same physical space. In producing home and work, zoning practice collaborated with, and was in part produced by factors such as advancing transportation technologies and consumer preferences in relation to land values.

Soon after the turn of the 20th century, localities began to try out different applications of regulation on land use, largely concerned with the presence of industrial activity in proximity to residences. Lawrence Veiller (1914) surveyed these nascent local approaches and posed the following question:

> *"…should we limit the industries or uses which we exclude from a residential district to certain specified ones that may be enumerated in the statute or shall we prohibit all industries in our residential district and forbid there any use other than for purposes of residence?"* (Veiller 1914)

In other words, he was asking a growing planning community if residential districts should be *entirely* free of commercial and industrial work, or free of *only* particularly noxious types of work. Examples of both approaches existed in early land use regulation.

A 1904 Los Angeles ordinance first prohibited only commercial laundry uses in new residential districts (“Ordinance No. 9774” 1904). A subsequent Los Angeles ordinance in 1909 gave an expanded, but still limited definition of what industrial activities would be allowed in residential districts (Veiller 1914). Yet the creation of exclusive residential districts was soon to become the more common approach. In Wisconsin, a 1913 law authorized cities to set aside districts for exclusive residential usage, which—although indicating the primary goal to be the exclusion of industrial use—also would not permit any commercial use (“Wisconsin Session Laws” 1913). Similarly, a 1913 New York State law authorized the creation of residential districts that permitted "no building other than a private dwelling" (“Laws of the State of New York” 1913).

Even as some zoning sought to prevent all commercial activities from comingling with residences, many plans encouraged clusters of retail businesses in areas near residential districts. For example a 1924 comprehensive plan proposal for the city of Boston promotes the “exclusion of factories, stores, and all businesses from residential districts”, however makes a distinction between what it calls “local business districts” and “general business districts”, with the former allowing retail uses including, bank branches, hotels, that were considered appropriate to be proximate to, but apart from, residential-only districts (“Zoning for Boston” 1924). Similarly, the planned community of Palos Verdes near Los Angeles informed prospective buyers that two small retail clusters would exist within its vast 3200 acres of largely exclusive residential use.

> *Local business centers of a few lots each, surrounded by a small group of apartment and house court sites have been established as a matter of convenience, about two miles apart. ("Palos Verdes The New City" 1925)*

Finally, in the 1930s a number of neighborhood rezonings in New York City sought to limit retail uses to select avenues while preserving residential uses on most streets (Cooper 1938). In each of these examples, planners sought to maintain or provide retail clusters nearby intended to meet daily needs of exclusive residential districts, even as major employment centers were kept at a greater distance.

A related land use regulation question centered on the regulation of different types of residential usage, notably multifamily compared to single-family use. As seen in the previous section multifamily tenement districts were perceived as locations of home-based work and unregulated manufacturing. Would zoning also be used to restrict new development in residential districts to single-family homes to the exclusion of multifamily housing? Multifamily tenements existed in all major US cities according to the 1890 Census, but New York City had nearly a quarter of the total multifamily units in the US, and nearly all of the units in buildings that housed seven or more families (Baar 1992). Furthermore, New York City, through the attention brought by *How the Other Half Lives* (Riis 1890) and other portraits of tenement life gave shape to their reputation, although other US cities, notably Chicago, contributed to this narrative as well. According to Baar (1992) even before the advent of zoning, regulations such as fire codes were used to discourage the construction of multifamily housing in Chicago, Boston, and Philadelphia.

Among the localities that created zoning plans that excluded multifamily housing was East Orange, New Jersey, which pointed to problems of "good residence streets" being "invaded" by apartment blocks (Coulston 1922). In another example, Bismarck, North Dakota, empowered by a 1923 enabling act, passed an ordinance forming a

residential district prohibiting buildings accommodating more than two families (Bismarck V. Hughes 1926). In New York City, commercial concerns had dominated the creation of the first US comprehensive zoning plan, as retailers in the 5th Avenue shopping district, reacting to the encroachment of textile manufacturing, were major advocates for the adoption of greater controls on development and use (Toll 1969). However, Fischler (1998) follows Plunz (1993) in expanding our attention beyond the dense area of Manhattan to the newly built areas in the boroughs, noting how the ordinance sought to protect and promote districts of one-and-two-family homes. Fischler argues that this tendency—though ultimately ineffectual—places New York City as less of an exception to other zoning ordinances that promoted single-family residential housing than previously thought.

The legality of exclusionary zoning ordinances that tried to restrict usage in areas to single-family residential use—keeping out not just industrial/commercial usages but also multifamily tenements—were debated with mixed outcomes by many state supreme courts in the early to mid-1920s with supporting decisions pointing to both moral and health reasons for excluding apartments (Baar 1992). Martha Lees (1994) points to zoning advocates acceptance at the time that the ideal home should be separated from sites of business and industry, provide a natural environment and promote good health. Ultimately, exclusive zoning to maintain single family residential use was upheld by the US Supreme Court in the case of *Village of Euclid et al. vs. Ambler Realty Co.* (1926), the first zoning case heard by the court. Although the 1926 decision declined to highlight any particular argument against multifamily as valid above others, it declares the full list of arguments it provides—which includes the tendency of multifamily buildings to

destroy the "the residential character of the neighborhood"—to be reasonable. In affirming exclusionary zoning for the purpose of single-family only residential districts, essentially promoting the "separation of homes from all else," the Unites States cemented a crucial difference in zoning approach compared to two of its European contemporaries, England and Germany (Hirt 2013).

The association of zoning with notions of good health and family-friendly environments was common through the 1920s. A regular Washington Post column by a physician advocated on behalf of the healthful benefits of zoning in 1924, arguing for "limitation of the height of buildings, less acreage, density of occupation, less crowding of the street cars, more sunlight in the streets and lower floors of buildings ... all of which means less disease, better health and more physical vigor" (Evans 1924). A "Zoning Primer" released by the US Department of Commerce to promote the adoption by states of enabling acts, makes similar claims about the healthful effects of sunshine and air. They also describe a family not using the rooms of their house for their intended purposes as an illustration of the need for zoning.

> *We know what to think of a household in which an undisciplined daughter makes fudge in the parlor, in which her sister leaves soiled clothes soaking in the bathtub, while father throws his muddy shoes on the stairs and little Johnny makes beautiful mud pies on the front steps.* (The Advisory Committee on Zoning 1926)

Finally, in 1929, as part of an early regional plan for the New York Metropolitan Area, architect Clarence Perry advanced his concept of the "neighborhood unit" as an ideal form for meeting the "universal needs of family life." He largely assumed workplaces

would be located beyond the neighborhood boundaries, and organized housing around a central public school, and with only those retail stores needed to serve the neighborhood on the outskirts.

The practice of exclusionary zoning has important intersections with race and sexuality. Indeed the 1904 Los Angeles ordinance to not permit commercial laundry use in residential districts was targeted at Chinese entrepreneurship ("Advocates Shotgun Remedy For Chinese Laundry Nuisance" 1906). Such overt racial zoning was ruled unconstitutional. A Kentucky zoning ordinance that forbid black occupation of residences in a white-majority block was overturned by the supreme court in the 1917 *Buchanan v. Warley* decision. Yet even after this decision, particularly in the Southern United States, cities attempted to achieve racial segregation through zoning, by enlisting the professional skills of planners to achieve segregation while staying roughly within the letter of the law (Silver 1997). Frisch (2002) points to contemporaneous beliefs that the lifestyle of multifamily housing exposed children to immoral lifestyles, and argues that by promoting single-family housing through zoning and other means, planning reinforced heterosexual norms.

Zoning to create exclusive single-family home residential districts without commercial, industrial, or multifamily use now rested on a firm legal foundation. Yet even in these areas, all work was not effectively banned from being done inside residential dwellings, it was only barred from being the principle use. Early examples of professions whose home work need not be threatened by residential zoning, as provided by a 1922 newspaper column on the issue, included professional and artistic occupations

such as dentists, architects, sculptors and music teachers. (“Protection by Zoning” 1922). A counsel for the New York Zoning Committee puts it this way in 1925:

> *“Professional persons can have their offices in their homes. Individuals carrying on customary home-industries like dressmaking and not employing others can work at home. They must not exhibit display signs for this is evidence that the main use is business. The test is that the main use is residential and that the business use is only incidental.”*(“Statement Shows” 1925)

Local zoning ordinances around the country handled the particulars of which work would be allowed and disallowed in residential-only districts differently but agreed on a core approach. The American Society of Planning Officials surveyed a sample of North American zoning ordinances in 1953, finding that most shared three qualities of acceptable home-based work; it should be a customary home occupation, incidental to the primary use, and not openly operating as a business (“Zoning Regulation of Home Occupations” 1953). In addition to barring the use of machinery and the display of signage, many “professional” occupations—doctors, dentists, lawyers, artists—were given specific allowance in ordinances, while the most commonly disallowed professions were beauty and barber shops (“Zoning Regulation of Home Occupations” 1953).

Increased adoption of telephones by US households, which reached 87% by 1970 according to the US Census Bureau (1999), does not appear to have greatly affected the practices of working from home. Through the 1950s and 1960s the home office was viewed as either ancillary or unrelated to office-based work, except for occupations permitted by many zoning ordinances, such as doctors and music teachers. Yet the concept of a dedicated “home office” space did emerge in these years, and was

envisioned as serving the needs of office workers doing work on evenings and weekends, sales and other mobile workers, as well as a place to pay bills and write letters ("Home Office Should Be A Quiet Place" 1969, Ellingson 1970). And it also became a concern of the Internal Revenue Service, which tended to view home offices as a source of illegitimate tax deductions (Weaver 1977).

Nor did zoning put an end to the larger-scale home-based manufacturing practices in tenement districts. In some cases, these areas existed prior to the implementation of the zoning ordinance, and already mixed commercial and residential activity, and thus could only be designated as commercial districts, which then functioned as mixed-use districts. ("Restrict Area to Private Homes" 1916). While zoning did manage the spread and reproduction of tenement districts, and regulated the physical characteristics of new building construction, it was left to labor laws to attempt to end to such practices. Regulations banning home-based manufacturing at the federal level as industry regulations under the National Recovery Act, were found unconstitutional by the Supreme Court in 1934 ("Ban on Home Work is Upset by Court" 1934). At the state level, Connecticut and Massachusetts tried to fill the void by moving to ban "sweatshop" labor in homes ("Massachusetts Seeks to Guard Home Workers" 1936). The *Fair Labor Standards Act of 1938* finally impacted the worst of home-based manufacturing through its regulation of child labor, minimum wages, and weekly hours, while the *Fair Labor Standards Amendments of 1949* granted greater authority for the regulation of industrial home work.

iii. Assuming the Separation of Home and Work in Land Use-Transport Modeling

Models of urban and regional growth that emerged in the 1950s and 1960s to confront problems of traffic, incorporated outcomes of early zoning both through an empirical reality that in part reflected zoning's influence on existing urban spatial arrangements, and through methodological decisions that framed land use in exclusive terms and centered on the relationship of residential use with non-residential use, particularly workplaces. Even as land use mapping detailed actual uses above zoned uses, planning assumed the separation of home from the workplace as they turned their attention to problems of growth and traffic; seen more as a natural function of economic spatial organization than as a result of intentional acts of planning. While "home" seems an inevitable origin point in transportation research, exclusionary zoning, through land use planning, influenced the framing of its usage.

The practice of planning with data on land use did not originate in cities, but rather emerged from rural county planning efforts in the 1930s, soon after which it was brought into city planning as a tool for understanding the outcomes of zoning regulations (Akimoto 2009). As early as 1941, land use mapping was stated as a core method within urban planning:

> *Urban land use maps in City Planning, are designed to meet several ends. The commonest is the "existing use" map as of some given date. Another is the "best use" map, and a third is the "future use" map.* (Goodrich, 1941)

Land use data was intended to inform the zoning process, or as a New York State manual for zoning put it, local planners making master plans should be "armed with the land use" before deciding on specific zoning ordinances ("Local planning and zoning", 1951). A 1943 Boston planning report did just this, using existing land use maps to propose that

one neighborhood be rezoned for residential use with “ancillary businesses only on chosen streets” (“Rehabilitation in Boston” 1943).

It was problems of traffic, and the relationship of traffic with land use, that would give rise to the practice of land use-transport modeling. Methods of transportation planning took shape in the first half of the 20th century as associations formed and societies of engineers took an interest in problems of roads and traffic. In 1916, the National Automobile Chamber of Commerce, an association of automakers, advocated for the development for a new expertise in highway engineering (‘Science of New Roads” 1916). In the same year, the president of American Association of Roads Builders, which had been founded in 1910, coined a term “speed weight” to consider damage from the stress of vehicles on roads (Foote 1916). The University of Michigan began offering a Masters of Science degree in Highway Engineering in 1920, stating that it intended to address a shortage of qualified highway engineers (Blanchard 1920).

Through the 1920s, interest bloomed in problems of traffic on newly busy roads, and particularly at intersections. Harvard University established the Albert Russel Erskine Bureau for Street Traffic Research in 1926, headed by its own graduate Miller McClintock. In 1928 the American Engineering Council organized a multi-city study of the use of traffic signs and signals to promote their sensible application in urban environments (“Two Fundamental Errors Made in Traffic Control” 1928). Finally in 1930 the Institute of Transportation Engineers was founded with planning consultant Ernest Goodrich as its president and traffic engineer Miller McClintock as its Vice President. By 1950 traffic engineers were employed by 82 cities and 43 states, and the

Institute of Transportation Engineers had crafted, in partnership with an association of Insurance companies, the 2nd edition of a *Traffic Engineering Handbook* (Evans 1950).

The sanctity and separateness of home surfaced in traffic engineering practices through the clear influence of planners, perhaps not surprising since its institute's inaugural president was a planner. The handbook's terminology section instructs engineers to think in terms of distinct land use districts—residential, business, and industrial. It also includes a definition of "neighborhood" that is directly derived from the Perry (2013) neighborhood unit.

> *A residential neighborhood meeting the needs of family life is characterized by four factors: (1) centrally located elementary school no more than 1/2 mile from any dwelling, (2) scattered parks and playgrounds to comprise 10% of whole area, (3) local stores on the periphery of the neighborhood, (4) a residential environment (architecture, planning, internal street system, deflection of through traffic). A collection of neighborhoods is termed a "community."* (Evans 1950)

The volume also taught the concept of studying traffic based on zones, and outlined basic traffic engineering principles drawing on engineering disciplines, planning, and psychology (Evans 1950). This inclusion of types of land use reflected an emerging understanding of the relationship between land use and traffic.

The notion of "commuting" which had its origins in seasonal railroad fares for regular travelers going long distances, first hinted at a shift to a broader meaning of journeys of workers to and from work by any mode, when the General Railroad Board of the Council of National Defense requested train travelers to substitute automobile travel for their regular train commuting journeys to make way for coal and iron freight in

support of the war effort ("Five Million Motor Vehicles" 1918). Although still largely associated with rail through the 1930s, the notion of "commuting" was used more broadly to refer to trips from locations more distant from cities—"commuting areas" that were served originally largely by rail ("New Transit Lines Vital" 1933). By the summer of 1943, the wartime Office of Price Administration used the term "commuting" to refer to automobile journeys in announcing that gas rations would be unavailable for those commuting from distant summer homes to their offices ("Gas Ration Banned" 1943).

However, the disciplines of traffic engineering and planning had not yet formulated methods for forecasting travel demand in a region, until the 1954 publication of *Urban Traffic: A Function of Land Use* (Mitchell and Rapkin 1954). The book emerged from work done in 1950 at the multidisciplinary Institute for Urban Land Use and Housing Studies at Columbia University (founded in 1948), in cooperation with the US Bureau of Public Roads based on their "growing concern with the problems of highway location, design and use in urban areas." F. Stuart Chapin in his review of the book, noted the "hen and egg" nature of the recent debate on the relationship between land use and traffic, stating that the book found a middle ground in this debate and a way forward towards a functional model of forecasting traffic (Chapin 1954). Mitchell and Rapkin frame urban movement as person trips occurring around bases, which illustrated with a recurring example of a suburban family.

> *Amos Pennyfeather lives with his wife and children in a Cape Cod Ranch house in the suburbs of Upsal Downs. Although he may not realize it, his home constitutes an establishment which is a residential base of operations for each member of the family…. The office is another establishment of which Amos is a member and*

> *serves as his work base. A great many other people converge on the same office at about nine o' clock.* (Mitchell and Rapkin 1954).

Mitchell and Rapkin (1954) ultimately outline a model for using estimations of movement based on land use for making design-decisions about transportation infrastructure, along with a list of the required data and a discussion of data collection.

The Chicago Area Transportation Study (1955) was founded on this idea that travel in an urban area is correlated with land use, and that predictions about future travel could be made given knowledge of current and future land uses. The final report states, "land use is the key to understanding trip making because it is the best available index to the activities which people undertake." The study inventories current land uses in quarter mile parcels, totaling within each, the percentage of residential, open space, transportation, manufacturing, public buildings, commercial, or parking. In explaining the patterns of the Chicago land use they observe, the study makes no mention of zoning or a role for planning in shaping observed land use, rather pointing to pressures of growth and the causal effects of transportation technologies. The separation of uses in the Chicago Area Transportation Study is explained as a natural economic tendency based on use:

> *Industry must have good transportation--railroad, highway or waterway. Businesses must be in locations having a high degree of accessibility to their trading areas. Residences must be located in areas where they can make their own favorable environment. For the most part, these activities cannot occupy the same land and therefore must necessarily be located in different places.*
> ("Chicago Area Transportation Study", 1955)

The study finds as expected, a strong relationship between residential land use and travel, with over 75% of trips in the Chicago region occurring between residential and non-residential land uses, and 40% of all trips between home and a workplace in one or another direction. They also find that the higher residential density of land use found in suburban areas on the outskirts, is associated with a greater number of family trips. This they explain as cost of congestion from mixed uses and density, writing, "it takes effort to walk to a bus or to get a car out of an alley garage," although they also admit that such areas "have a variety of activities sufficiently packed together so that vehicular trips are less necessary" ("Chicago Area Transportation Study", 1955).

The role of land use as an input in planning methodologies continued to develop through the 1960s supported by the computational capabilities of computers. Ira Lowry's *Model of Metropolis* (1964) was published through the Rand Corporation in 1964 although work had begun on it in the late 1950s. The model's initial inputs are basic employment, and the available land for residential and retail usages, from which it iteratively derives projections of retail and residential growth locationally assigned within the region to geographic zones. For its trial run with data from Pittsburgh, retail employment was assumed to take place in one of three types of clusters based on the type of business: neighborhood, local, or metropolitan. Lowry frames this decision as a concession to computing limitations. But these clusters also reflect the different types of business cluster permitted by zoning and in the concept of the "neighborhood unit" which groups retail on the outskirts of residential areas.

Computerization imposed other limits on the complexity of models. For example Lowry's Pittsburgh model not only had to be simplified in terms of the number of the

categories of retail trade in order to shorten the use of computer time. Lowry also notes that the published model with 650 units of area (a square mile each), took about 17 minutes to run on an IBM mainframe, and that the run time was highly sensitive to the geographical grid size (Lowry 1964). Guttenberg (1959) provided planners with a standardized computer-ready land use classification system in which a single computer punch card would represent one parcel of land along with its primary use, but noted that representing mixed use parcels would require an additional card for each parcel of land.

Present and future zoning restrictions could be included in models as a restriction on the availability of land in future iterations representing time periods. In the Chicago Area Transportation Study, consideration of zoning and plans was excluded from even the explanation of current land uses, but it is used as one input in determining predicted future land uses that are then used to estimate future travel demand. Lowry (1964) took consideration of zoning laws in his allocation of available land for his Pittsburgh Model. A model developed for the 1959 Penn-Jersey Transportation Study proposed the addition of zoning restrictions as a way to compare alternate futures when input as available residential land or left out of the model to indicate a lack of regulation (Herbert and Stevens 1960).

Large-scale models were closely related to efforts to improve theories of location. Prior to the 1960s most economic theories of location were concerned with firm location. Marshall (1898) for example offers an explanation for concentrations of specialized firms, while Isard (1959) devotes most of his survey of urban location theory to issues of industry location, only discussing the mobility of labor, but not extending that to include concern for their residential location within the region. William Alonso (1964) modeled

the value of residential uses, which he explained as a function of the price of land, the price of commuting, and the enjoyment of time not spent commuting. The costs of the journey between work and home is fundamental to Alonso's model, which represents an elevation of the work-home commute to a central element in urban growth.

One of the challenges Alonso encountered in the adaptation of previous theories of land value to US urban land stemmed from an observation that in US cities, the poor tended to be in the city center whereas those of greater means lived further afield. In confronting this challenge, Alonso too makes an assumption about the separation of home and workplace, in the form of imbuing his actors with a preference for low-density dwelling:

> *... given two individuals of similar tastes, both of whom prefer living at low densities, if their incomes differ, the bid-rent curves of the wealthier will be flatter than those of the man of lower income. Therefore the poor will tend to central locations on expensive land and the rich to cheaper land on the periphery. The reason for this is not that the poor have greater purchasing power, but rather, that they have steeper bid rent curves. This stems from the fact that at any given location, the poor can buy less land than the rich, and since only a small quantity of land is involved, changes in its price are not as important for the poor as the costs and inconvenience of commuting.* (Alonso 1960)

While not invalidating the model, it is an assumption that hearkens back to the tenement era in which dense areas of the city center were considered to be undesirable for residency.

Modeling land use and transportation gained momentum, and an influence that lasts through the present day, starting with the 1962 Federal Highway Act. The original 1956 Federal Highway Act under President Eisenhower planned for 33 billion dollars in Federal spending over 13 years towards building an interstate highway system, funded by creating taxes on fuel and establishing a Highway Trust Fund ("800 Million in New Roads" 1959, "Public Law 627" 1956). Yet the formula was soon not seen as sufficient to keep pace with demand for roads (Kilpatrick 1960). Recognizing the need for regions to plan their growth, the 1962 Federal Highway act included a requirement for urban regions to engage in a "cooperative, comprehensive, and continuing planning process." Subsequent federal laws in the 1960s, including the 1964 Urban Mass Transportation Act, and 1967 Air Quality Act followed suit in requiring regional planning (Johnson 1970).

iv. Conclusions

Exclusive residential districts of single-family homes had three qualities that promoted the separation of home from the workplace. Firstly—indeed definitionally—they excluded employment-generating industrial and commercial activities from certain geographical locations, thereby necessitating that new enterprises locate in different areas. Secondly, single-family residential districts tended to be further from central business districts, while zoning ordinances supported only less dense retail-oriented versions of commercial use districts in residential-adjacent areas. Thirdly, in excluding multifamily housing they removed spaces that were perceived as less regulated and where home-based work had previously existed in both its exploitative and empowering forms.

While it is rational, and even inevitable, that "home" as the place where one beds for the night became the lynch pin of travel forecasting in the 1950s, the form of its usage was shaped by previous decades of planning. The separation of home from work that occurred in the first decades of zoning shaped early large-scale models of urban growth by two pathways. Firstly, the empirical reality of US cities did not wholly reflect the outcomes of a natural urban system but rather included the effects of zoning. Secondly, the discipline of planning had passed on to traffic engineering its practices of planning through distinctions between uses, based on the needs and wants of each use, yet this understanding was not applied critically. The Chicago Area Transportation Study (1950) stated that 'the use of land is a tangible, stable, and predictable quantity' in arguing for its role as an input in modeling future travels patterns. Yet as this chapter has shown, the discipline of planning itself had some role in giving land use these qualities. Planning created land use as a quantifiable and predictable entity—land use is predictable only to the extent that it was made predictable by zoning laws: Home was more effectively separated from workplace through intentional acts of planning, which then made land use a better predictor of travel demand.

In the 1970's urban scholars turned a critical eye towards such applications of land use travel forecasting, and current conceptions of land use. Douglas Lee (1973) published a *Requiem for Large-Scale Models* listing the ways in which computerized models of the sort referenced in this chapter fell short of serving the needs of planners. The Urban Land Institute introduced mixed use developments as a new form of land use (Witherspoon 1976). Attention also turned in that decade to the concept of subcenters, disrupting assumptions of a single urban core (White 1976). Finally, the 1970s was also

the decade which saw the emergence of the substitution of telecommunications for travel—telecommuting—which is the subject of the next chapter. While the distinction between “home” and “work” and the prominence of the “commute” is still a part of planning, as is computerized regional modeling, its applications have become more careful and complex, for the better.

Chapter 3: A Long Groundwork for Reconfiguration: Telecommuting Advocacy in the United States as a Case of Strategic Niche Management

The questions of how societal practices change over time in relation to technology, and the extent to which planning and policy can guide this change towards more beneficial outcomes are fundamental to planning and public policy. Notions of a simple substitution of one technology for a more sustainable alternative belie the complexity of sociotechnical systems. In this chapter I use the example of three decades of telecommuting planning and advocacy to add to a growing body of literature on such sociotechnical transitions. Telecommuting emerged in the early 1970s as a strategy to confront societal problems related to the journey between home and workplace. Automobile traffic and its relationship with land use had become a central concern of planning in the United States by 1970, particularly in its connection to challenges of road congestion and air quality. I frame the decades-long efforts of its advocates to advance the notion of telecommuting, as an example of strategic niche management, a practice in which technological innovations are managed in the long term to help engender a beneficial change within a socio-technical system (Kemp et al. 1998). The planning of telecommuting in its first three decades shows fundamental elements of strategic niche management as defined by Schot and Geels (2008): a vision and expectations, learning processes, and social networks among advocates, while providing protected spaces for the practice of telework. While the first decades of telecommuting innovation predate the concept of transition management, this chapter argues that its actors and practices provide an early case of strategic niche management from which future practice can learn.

After an introduction of the concepts of strategic niche management and multi-level perspective on system change, and how these concepts will be applied to the case of the history of telecommuting advocacy, this chapter describes the origins of the notion of telecommuting in Los Angeles California. The next sections review how trip reduction and travel demand management policies opened up protected spaces for telecommuting and other related innovations, and how public agencies were early experimenters of telecommuting. The next section examines how the evaluation of pilot programs formed a shared learning process that informed telecommuting advocacy, and gives examples of advocacy in the 1990s, such as guides and events used to promote the wider adoption of telecommuting among firms. Finally, the conclusion considers the outcomes of telecommuting as strategic niche management, using the four pathways of socio-technical system change defined by Geels and Schot (2007), finding that it laid a groundwork for a "reconfiguration" pathway, but in part due to a weakening of the original vision of telecommuting, its sustainability benefits are unclear, and the ultimate outcome depends on factors beyond the control of niche advocates.

i. Strategic Niche Management in Sociotechnical Transitions

Social systems and technical systems are inexorably bound and best treated as single "socio-technical systems" (Trist 1981). For planning and public policy, the management of change within complex sociotechnical systems, such as toward more sustainable practices, can be realized by the application of long-term thinking to guide short-term decisions (Rotmans et al. 2001). Geels (2002) offers the layered multi-level perspective (MLP) as a framing concept for understanding how such systems undergo change. The MLP envisions a sociotechnical system as having an upper landscape layer

containing institutional lasting structures, a middle regime layer representing established ways of operating, and the bottom niche layer in which radical innovations develop (Smith et al. 2010). Changes to the regime layer can result from different combinations of top-down landscape pressure (ie. broad changes in socioeconomic conditions or societal values), and the bottom-up adoption of niche innovations. For Geels and Schot (2007) change comes by four pathways: *transformation* when pressure from outside groups prompt the adoption of innovations, *realignment* when problems within the regime have no clear solutions and spur a search for innovations, *technological substitution* where niche innovations have matured when a shock prompts their widespread adoption, and *reconfiguration* where innovations are adopted piecemeal to solve specific problems prompting a change process within the regime.

Strategic niche management is an explicit effort to control the development of niche innovations through "protected spaces that allow nurturing and experimentation with the co-evolution of technology, user practices, and regulatory structures" (Schot and Geels 2008). Protected spaces shield innovations from being ignored, nurture them in their development, and ultimately empower them to exist beyond boundaries of protection (Smith and Raven 2012). Barriers to the adoption of niche innovations include landscape or regime factors such as market demand, regulatory frameworks, or cultural practices (Kemp at al. 1998). Successful strategic niche management is characterized by three factors: a clear articulation of vision, multi-level learning processes, and the building of social networks among advocates (Schot and Geels 2008). I use these factors, as well as the notion of protected space to identify telecommuting as a case of strategic niche management. Usually the creation of niches is by outsiders, but regime actors can

also play a role in their development and in steering transitions broadly (Kemp et al. 2007).

Transportation systems have been of interest to authors within the sociotechnical transitions literature. Geels (2002) uses personal land transportation as an example of how "societal functions are fulfilled by sociotechnical configurations", showing how the notion of personal driving binds together vehicle technologies, infrastructures for road and fuel, systems of regulation, distribution networks for vehicles and supplies, and cultural meanings concerning freedom and independence. Cohen (2010) uses an example of a marketing niche innovation in the growth of private commercial aviation to show how innovations are not always technical nor always moving towards the goal of more sustainable systems. Finally Hoogma et al. (2002) use innovations such as electric vehicles and car sharing as examples of how niche innovations often struggle to advance beyond the demonstration project stage. Indeed, critics of the early transition management literature pointed to the dominant role of technological innovation as the starting point for transition, and have called for more attention to the social practices of individuals in society as a means to understand challenges to achieving transition. The example of a generational shift from weekly to daily bathing serves as an example of how technologies are yet one part of a practice which is also embedded in cultural meanings (Shove and Walker 2010).

The sociotechnical system that is of concern to this research is that of professional and administrative work location which largely takes place in office buildings. This system as conceived here in terms of the multi-level perspective as shown in Table 1.

TABLE 1: Professional and Administrative Work Location in the Multi-Level Perspective

Landscape Layer		Values related to home and workplace Urban form/ Transportation infrastructure Computing infrastructure Economic conditions
Regime Layer		Workplace policies and norms Project/team social practices Manager attitudes and social practices Employee attitudes and social practices Daily travel
Niche Layer		Home-based telecommuting Center-based telecommuting Flexible work location policies

Telecommuting is considered as a set of niche innovations, which may be adopted by a regime layer that consists of the policies and norms of firms towards alternate work locations. The landscape layer—consisting of the spatial layouts of communities, the values given to workplace and home by individuals, and computing infrastructures—puts pressure on the regime, which may impact its practices and influence the adoption of innovation. It is notable that workplace computing infrastructure changed greatly during the decades under consideration, from centralized mainframe systems controlled through input terminals, to the introduction of personal computing, and finally to mobile cloud computing enabled though the Internet. These changes exerted landscape pressure on regime work location practices. However the focus of this chapter is not on these important changes to computing infrastructure, but rather on the efforts of advocates working across the time period that these changes occurred. I will show that telework advocacy in the United States represents an effort at strategic niche management in that through the concept of "telecommuting", it possessed a clear vision for solving societal problems related to the automobile, and that its advocates shared knowledge and coordinated activities in seeking protected spaces for the practice of telework.

ii. California Dreaming: Telecommuting Vision and Context

Urban California in the 1970s, and especially Los Angeles, is an unsurprising place for the emergence of an innovation that seeks to reduce automobile usage, given the prominence of auto-related problems of congestion and vehicle-related air pollution in its modern history. What success new freeways had found in the early 1950s at reducing traffic congestion did not do much to dampen LA's reputation for traffic jams (Hill 1953, Mullen 1967). Yet even so the first "freeway revolt" grew out of local opposition to an extension of the Embarcadero Freeway in San Francisco, before emerging in other cities in California and around the US (Mohl 2004). California's longstanding policy of freeway building in response to travel demand had become financially unsustainable by the mid-1970s, which also supported a shift toward multimodal transportation planning (Taylor 1995). Air pollution too, in part related to vehicle emissions, was a growing problem. In 1955, a particularly long spell of "smog" (an amalgamation of "smoke" and "fog") prompted the city of Los Angeles to issue its first smog "alert" to warn residents of the danger (Hill 1955). Vehicles, along with heavy industry and mountain ranges that trapped pollutants, were considered to blame for the poor air quality.

The Federal Clean Air Act of 1970, required metropolitan regions to meet standards on five categories of pollutants starting in 1975. Los Angeles was one of three large cities nationally to fail to meet any of these standards ("EPA Says" 1975). Several policy initiatives aimed at reducing automobile travel were undertaken in California in response to problems of congestion and air pollution. The Santa Monica Freeway in Los Angeles was one of the first to implement in 1976 what came to be called a High Occupancy Vehicle Lane (HOV), in which one lane of traffic during rush hour was

devoted entirely to bus and car pool traffic, alongside regular lanes on a freeway ("Express Car-Pool" 1976). In 1978, the South Coast Air Management District (SCAMD)—formed a year earlier to coordinate pollution control efforts under Federal and State regulations—announced antismog rules which temporarily closed parking facilities for employees not participating in car pools, and encouraged avoiding unnecessary driving in periods of extreme smog ("Antismog Rules Imposed" 1978).

Enter telecommuting: Jack Nilles was Director of Interdisciplinary Research at the University of Southern California, located in Los Angeles, when he led the publishing of *The Telecommunications-Transportation Tradeoff in 1976*. The primary case study research presented in the book—a hypothetical telecommuting scenario based on data provided by an insurance firm—had been funded by a National Science Foundation (NSF) grant under the Research Applied to National Needs (RANN) program (Nilles 1974). This NSF program was created by the Nixon administration in 1971, and granted nearly half a billion dollars for the solving of societal problems through the multidisciplinary application of physical science, social science, and engineering, before it was ended in 1979 (Green and Lepkowski 2006). The societal problem that was identified by Nilles et al. in *The Telecommunications-Transportation Tradeoff* (1976) was the environmental and economic costs of automobile commuting. A future-oriented long view was evident in the subtitle of this first book on the topic of telecommuting: "Options for Tomorrow" (Nilles et al. 1976). In addition to demonstrating that telecommuting could conserve money and energy and reduce traffic congestion, Nilles showed a clear vision for a future role of telecommuting in society, and articulated expectations for its implementation. He explains his use of the term "tradeoff" as pointing

to a need to evaluate the specifics of the contexts in which it is applied and acknowledges that it is not appropriate for all types of jobs (Nilles et al. 1976). As shown later in the chapter, these expectations were shared with other advocates, with implications for the way the innovation of telecommuting interacted with regime work location practices.

It was in planning the 1984 Olympic games that telecommuting was first tried out as a policy tool on a wide scale. In 1978, Los Angeles was selected to host the so-called "freeway Olympics"—named because of the great distances between venues— and traffic congestion was considered to be a primary potential problem (Lindsey 1983). A comprehensive transportation management strategy (TMS) created in advance of the games featured a system of shuttle buses, but also included efforts to manage demand among non-spectators in the form of requests to local employers to shut down for periods or to alter work schedules (Lindsey 1984). A set of policy recommendations from the Metropolitan Planning Organization in a campaign entitled "The Olympic Legacy: Let's Keep it Moving" included recommendations for employers to use flex times and provide opportunities to work from home *("Transportation Policy Recommendations").* In response, some companies shifted employee work schedules, and Pacific Bell launched its first telecommuting program using suburban subcenters and some employees working from home (O'Leary 1991). For the public broadly, a set of PSAs included a message from celebrity Phyllis Diller telling locals "don't drive unless you have to" ("Olympic Celebrity PSAs – 1984"). The Olympics passed without any major transportation problems, with much of the credit being claimed by the Olympic special bus service, but a simulation analysis conducted afterwards on actual travel data examined the contribution of non-spectator demand management, finding that the elimination of work

trips improved freeway speeds by 31%, and that work scheduling contributed an additional 5% (Giuliano 1988).

iii. Defining Protected Spaces: Telecommuting in Trip Reduction and TDM

Around the time of the Olympics, telecommuting became aligned with other innovations, such as flexible work scheduling and carpooling, which could in the right configurations, reduce the demand for automobile travel. Advocates of these innovations shared concern for the societal problems related to the automobile journey to work of traffic congestion and air quality. A "protected space" for the development of these innovations would be a situation in which further experiments could be carried out in a real world context where they can co-evolve along with organizational policies and individual preferences concerning them, and be evaluated. Protective spaces should shield, nurture and empower niche innovation (Smith and Kemp 2012). For telecommuting and its related demand-oriented innovations, protected spaces took the form of trip reduction mandates and standardized policies of transportation demand management (TDM) at the local, state, or federal levels that created incentive for the practice of telework.

Trip reduction, which was used in the Los Angeles region as a temporary strategy in periods of heavy smog and during the Olympics, was first approved as a full-time measure—Regulation XV—by the South Coast Air Quality Management District in 1987 affecting firms with 100 or more employees (Stammer 1987). A trip reduction policy consists of a suite of measures designed to reduce auto travel. It was considered necessary as a means to reduce air pollution from mobile sources to meet air quality standards established under the Clean Air Act. Opposition from the businesses that would

be affected by the measure was limited at the time because of a fear of Federal sanctions in response to the failure of the region to attempt in good faith to meet air quality standards, and because the plan removed some pressure from industrial firms that emitted pollution from stationary sources (Oren 1998). At a local level trip reduction ordinances emerged from the mid-1980s, most often to deal with problems of traffic congestion, or else in larger municipalities and counties a combination of traffic congestion and air quality (Jewell et al. 1990). A 1990 survey of local policies formed in the 1980s found that over two thirds of US trip reduction ordinances were in California (Ferguson 1990). The City of Los Angeles had passed its own trip reduction ordinance, months before Regulation XV, citing both air pollution and traffic congestion as reasons (Stammer 1987).

At the state level, trip reduction legislation could mandate the creation of and provide guidance for local ordinances. Concern about air quality was the primary stated motivation in the adoption of other early state trip reduction programs in Arizona and Washington. Arizona's 1988 Air Quality Bill was passed after a lawsuit mandated the creation of a State Implementation Plan (SIP) for air quality. Due to its poor air quality at the time, the law required that employers in Maricopa country, including Phoenix, with 100 or more employees implement a trip reduction plan. Washington State's 1991 Commute Trip Reduction law similarly impacted large employers in urban areas ("70.94" 1991). In California voters approved—by a slim margin in 1991—Proposition 111 which doubled the gas tax, approved spending on highway and mass transit projects, and approved the congestion management program (CMP) requiring counties with urbanized areas to prepare trip reduction plans. The State of Hawaii Department of Transportation

conducted an experiment in trip reduction from employee use of shared teleworking centers located close to the neighborhoods where they lived; the 1990 center was so successful a second one was planned in 1994 ("Report to the Governor" 1995).

At a Federal level, legislation mandating employer trip reduction had a short and controversial history. The Clean Air Act Amendments of 1990 included a requirement for states with metropolitan area failing to meet ozone standards to implement an employer trip reduction (ETR) program. This requirement, which was added in conference, was not widely noted at the time of the amendments bill passing. However in 1995, after complaints from affected states about the effectiveness, costs, and hardships of car and vanpooling, the program was amended by Congress to be made voluntary ("H. Rept. 104-387" 1995-1996). Among the evidence presented were the challenges of dual career families to carpooling, and the experiences of Compaq computer which invested in carpooling, bus service, bike facilities, and telecommuting, but yielded only minimal change to its employee commuting.

As for the specific innovations that employers could adopt to comply with trip reduction policies, carpooling and vanpooling took center stage. However telecommuting was often present as an option. Like many ordinances, the Los Angeles trip reduction plan left firms to decide how to achieve the target reduction of employee trips—with "telecommuting" among the board's suggestions—however the plan was largely viewed at the time as a "ride sharing" measure promoting employee car and van pooling (Stammer 1987, Milstein 1988). While Washington's law initially did not mention "telecommuting" as a strategy, the Washington State Energy Office had conducted the Puget Sound Telecommuting Demonstration a year earlier, which incorporated both

home-based and center-based telecommuting for 280 telecommuters at multiple organizations in the region (Ulberg et al 1993). The guidance included in California's Congestion Management Program listed primary strategies as "carpools, vanpools, transit, bicycles, and park-and-ride lots; improvements in the balance between jobs and housing", while listing telework as one of "other strategies, including, but not limited to, flexible work hours, telecommuting, and parking management programs" ("65088 et seq." 1990).

The protected spaces that allowed experimentation with telecommuting and other travel demand-reducing innovations were distributed unevenly in the United States. Efforts to mandate their creation at the Federal level had failed, leaving states such as California, Washington, Arizona, and Oregon as leaders in trip reduction legislation. Yet the discipline of planning helped to promote the adoption of trip reduction more widely. From the late 1980's telecommuting was nearly always considered as an option for the elimination of trips in trip reduction plans, and was often paired with flexible work hours as a strategy. And by the turn of the century telecommuting was codified as a standard part of what came to be most widely known as travel demand management (TDM), and was listed as one of six key goals in a model TDM statute in the influential *Growing Smart Legislative Guidebook* (Meck 2002). Yet for firms to more widely adopt telecommuting within protected spaces, advocates needed to also supply examples of its practice and knowledge derived from an assessment of that practice.

iv. Experimenting Through Public Employee Telecommuting

The protected spaces provided by trip reduction mandates and TDM policies—even if limited to a small number of states and not successfully mandated from a Federal

level—provided opportunities for experimentation with telecommuting and other demand management strategies. Furthermore the idea of trip reduction and the potential of telecommuting had spread—in part through the discipline of planning—beyond just those places where legislation had been successfully implemented. For advocates of telecommuting, some of whom inhabited transportation and energy agencies, public employee telecommuting was a convenient context in which to conduct pilot programs at both small and large scales. The connection between trip reduction policies and public employee telecommuting is evident in that most of the first states to try telecommuting were also the first to implement trip reduction. Public agencies, alongside seeking other benefits, sought to demonstrate the trip reduction they were requiring of firms.

The State of California used its own employees to test the potential of telecommuting, with the same goals of reducing traffic congestion and protecting air quality, but also the productivity-minded concerns of saving money on office space and energy, and increasing the effectiveness of work. The project was first proposed in 1984, planned in 1985, and came to fruition in 1988, with 17 departments and offices of state government allowing over 300 employees to conduct at least some work from their homes over the course of the pilot (Kitamura 1990, Nilles 1990). It had the support of the Governor, through a 1988 executive order that mandated trip reduction for state workers, including expediting the pilot program (Deukmejian 1988). The Governor signed an executive order after a 1989 earthquake in the San Francisco region, ordering agencies to reassign affected employees to office locations closer to their home and to implement telecommuting policies to allow more employees to conduct work from home (Deukmejian 1989). Finally the California State Telecommuting Program became law in

1990, at which time the department of General Services created an office to oversee agency telecommuting programs ("14200-14203" 1990).

The other states that were early experimenters with telecommuting for employees included the same states that enacted early trip reduction legislation, Arizona and Washington. Arizona piloted a telecommuting program for state employees in 1988 that was formally adopted through an executive order in 1994, with reference to the state's Air Quality Bill and the requirement of private large employers to reduce trips (Symington 1994). In Washington State, the 1991 Commute Trip Reduction law contains a section with regulations for state agencies, requiring them to develop trip reduction plans, and encouraging the department of transportation to "promote consistency" among agency trip reduction policies ("70.94" 1991). Florida enacted a state telecommuting program in 1990 that authorized state agencies to submit proposals for telecommuting programs to the Department of Administration, which oversaw and evaluated them ("State employee telecommuting program" 1990). The statute was made permanent and remains in place today. Finally, in Virginia, the General Assembly resolved in 1990 to study the feasibility of telecommuting resulting in a recommendation to start a program citing the benefits of telecommuting as "traffic congestion, environmental and societal", that was enacted in the following year (Virginia Employment Commission 1990).

The Federal government was also an early experimenter with telecommuting arrangements, with air pollution and cost savings as stated key motivators. In the late 1980s, the US Environmental Protection Agency (EPA) began a pilot program that allowed some employees to work from home (Weisskopf 1989). It was an implementation of the Federal Flexible Workplace Pilot, called "Flexiplace" for short.

Frank Wolf, a Republican congressman from Virginia—where many Federal workers lived—advocated for this policy spanning multiple Federal Agencies each with its own implementation, and introduced a 1990 bill to fund the installation of phone lines in employee homes to allow workers to connect to government databases (Causey 1990). A document outlining the implementation at the EPA lists automobile-related concerns as a key reasons for its adoption:

> *EPA is expected to be a leader in promoting new methods to reduce risk and prevent pollution. Commuting-based traffic congestion and associated air pollution emissions can be reduced by applying alternate work scheduling and work deployment techniques.* (Environmental Protection Agency, 1991)

The policy combined time scheduling changes with telecommuting options, but officials and supervisors had total control over which employees could participate in the program. Flexiplace was also implemented at other agencies, including the Agriculture Department, the General Services Administration (GSA) and the Justice Department (McAllister 1993). By 1992, 550 federal workers had enrolled in the program, although this was below a projected 2000 workers (Taylor 1992).

The General Services Administration's experiments revisited the earliest notions of telecommuting arrangement, in funding the opening of new satellite telework centers on the outskirts of Washington DC, such as the Shenandoah Valley Telecommuting Center in Winchester Virginia, to accommodate Federal employees who live more than three hours total commuting time distance from a main office. (Fehr 1993). The telecommuting centers, which numbered 17 around Washington at their peak in 2000, were run through local organizations utilizing GSA funding. Federal agencies were

initially subsidized in their use of the centers and had to pay only $5 per worker to spend a day at the center, although that amount was planned to increase to $20 in hopes of making the centers financially sustainable (Gardner 1995). The GSA experimented with telecommuting centers in other regions, such as one that was built for Veterans Administration workers outside of Los Angeles in the aftermath of the Northridge Earthquake (Gore 1997). The GSA had already opened up many centers to private sector use, and closed several because of lack of use (Ginsburg 1999), when a 2001 evaluation of the program found that all but one of the Washington telecommuting centers were underutilized and losing money, and recommended ending financial support for them ("An Evaluation Of Feasibility Of Telecommuting Centers" 2001). Federal funding for most centers was withdrawn in 2011, leaving local partner organizations to decide their fate (Alexander 2011).

In addition to environmental concerns and productivity, working from home through Flexiplace, and the GSA-sponsored telecommuting centers located close to exurban homes, were considered as part of a set of policies aimed at making the workplace more supportive of families (Jones 1994). Other "family-friendly" policy initiatives included day-care, job sharing, leave sharing, and allowing Federal workers to use sick days for adoption purposes (Casey 1991). These efforts partly stemmed from findings that the government was not keeping up with the private sector in adapting its workplace to the needs of families (Taylor 1992). Al Gore, in his 1993 report *Creating a Government that Works Better and Costs Less: Report of the National Performance Review*, lists telecommuting as one component of a family friendly workplace, and

encourages the Department of Transportation to both implement and evaluate the potential of telecommuting to reduce travel (Gore 1993).

In addition to public agencies, utility firms were also early experimenters with telecommuting arrangements. Mountain Bell first considered a telecommuting pilot program in 1979, and launched a test in 1980 in which managers whose job consisted of writing instructional material were permitted to work from home, which led to more programs with suitable jobs and willing managers being tried. After a positive experience with a temporary telecommuting program during the 1984 Olympics, Pacific Bell launched a permanent program that had telecommuters working both from home, and from centers located in suburban areas outside the central business district (Leary 1991). Bell Atlantic had a popular telecommuting program in place from 1993 for managers, but fearing lower salaries for home-workers the union vetoed a proposal from the company for a plan to introduce telecommuting for non-management roles (Stets 1995). Early-adopter public agencies and such utility firms were not just experimenters with telecommuting; they were often also participants in a community of telecommuting advocacy that shared knowledge about its outcomes and which reached a peak in the late 1990s.

v. Shared Learning and Practice: Assessing and Advocating for Telecommuting

Assessing Telecommuting

The original study of telecommuting was a hypothetical scenario, but was based on data collected from an insurance firm, and its publication provided the basis for *The Telecommunications-Transportation Tradeoff* (Nilles et al. 1976), which offered guidance for new practitioners, particularly on the types of "information industry" work

that were applicable for telecommuting. But it was efforts to evaluate early telecommuting pilots—some of which involved Nilles' consulting firm—that sought to create the detailed knowledge that could inform future programs and telecommuting advocacy. The questions that were of interest to the community that studied telecommuting were its impact on travel and productivity, as well as the views and experiences of managers and workers regarding telecommuting.

Most program evaluations and studies of the effect of telecommuting on travel found that it does work in its primary goal of reducing travel. For the 1988 California state worker pilot project, travel diary data was collected from telecommuting workers as well as members of a control group; results showed an expected reduction in weekly work trips due to substituted work trips, but also a reduction in nonwork trips by family members (Kitamura et al. 1990). The effect of telecommuting from neighborhood work centers on travel was tested through the Residential Area Based Offices (RABO) project in California finding that while number of trips was not affected (since participants still needed to commute to the neighborhood centers), they traveled fewer miles on telecommuting days (Balepur et al. 1997). Using vehicle miles traveled (VMT) as the dependent variable rather than trips, as well as an aggregate national panel data set compiled from multiple sources spanning 1988 to 1999; another study finds that telecommuting has a small yet statistically significant negative effect on VMT (Choo et al. 2005). A meta-analysis considered 35 empirical studies of the effects of telework, and found that nearly all of them showed the relationship between telecommuting and travel to be one of substitution of telecommunications for travel, in which telecommuting reduced travel (Andreev et al. 2010).

However another early promise of the benefits of telecommuting for firms was that it was a way to increase productivity. Here, evaluations found that while telecommuting *can* increase productivity, in its wider applications it has not greatly affected productivity. An analysis of Fortune 100 company pilot programs found that productivity was unchanged among home workers compared to in-office workers, yet managers preferred to have workers in the office (Olson 1989). Westfall (2004) points to the very failure of telecommuting to be widely adopted as evidence of its minimal impact on productivity, arguing that economic logic would dictate its widespread adoption in the face of even relatively small real productivity gains. Where productivity gains have been found is with cases of structured work with measurable outcomes. An early and oft-cited successful example of telecommuting productivity is a 1980 program at Blue Cross/Blue Shield in South Carolina, wherein home-based workers filed 50% more claims per day with 50% less errors ("Work From Home By Computer" 1987). An empirical study on the determinants of telecommuting productivity showed that it was the existence of an internal method of evaluating telecommuting outcomes that was most important to both productivity and to home-based employee satisfaction with telecommuting (Hartman et al 1991). Similarly, DuBrin (1991) found that both productivity and satisfaction of home telecommuters doing repetitive tasks was higher than in-office workers. The California State worker pilot program found that management and supervisor support, as well as adequate training were essential to success, and that telecommuting only be applied to jobs for which it can be effective.

The adoption of telecommuting also rests on worker and manager satisfaction. A study of attitudes toward telecommuting in 1988 found that managers had a slight more

negative view of telecommuting than employees, but that both groups had concerns about the effect of working from home on career development (Duxbury et al. 1987). Professional isolation, defined by the extent to which employees engage in professional development activities, was found to be problematic for telecommuters since such activities are often informal or spontaneous, such as the interpersonal networking of water cooler talk, and the informal learning that takes place in cubicle huddles (Cooper and Kurland 2002). Interviews with employees in a 1998 empirical study of IBM telecommuters convey that the lack of face-to face office interactions resulted in feelings of a negative effect of telecommuting on teamwork, and also found the flexibility benefits to work-life balance felt by telecommuters were offset by feelings of blurred boundaries between work and home (Hill et al. 1998).

Among advocates and practitioners of telecommuting—which in the 1990s included those at DOTs, other government agencies, utility firms, firms affected by trip reduction policies, telecommuting consultants and new advocacy organizations—the knowledge generated by pilot evaluation and academic studies was both influential and shared. For example, the study on telecommuting commissioned by the state of Virginia was instructed to learn from the experiences of California with telecommuting, as many others did as well (Virginia Employment Commission 1990). By the 1990s telecommuting advocates faced a situation in which, on the basis of shared knowledge, telecommuting appeared to have clear benefits for trip reduction, yet no clear effect on productivity except in very specific circumstances, and mixed feelings among workers and managers.

Advocating for Telecommuting

In seeking wider adoption of telecommuting, its advocates turned to creating materials to guide firms towards successful applications of telecommuting. As they did so they created the shared expectation that telecommuting success was dependent on carefully structured programs setup in specific contexts. Four common strategies for advocating for telecommuting were used, which were not mutually exclusive of one another and were most often applied in some combination. One strategy was to *promote telecommuting in carefully selected and structured circumstances*. A second strategy was to *highlight the benefits to organizations from this selective application of telecommuting*. A third strategy was to *promote telecommuting on the basis of its benefits to the societal problems of traffic congestion, air quality and energy usage*. A fourth strategy was to craft materials to *anticipate the resistance of upper and middle management* to telecommuting. The following examples of the promotion of telecommuting will serve to illustrate how these strategies were applied in combination. What is notable about these strategies is that in making firm benefit central to their advocacy, they promoted telecommuting for organizational gain above the societal benefits that originally inspired telecommuting. This limited adoption of a niche innovation to meet specific needs conforms to the patterns of a *reconfiguration* pathway of system change identified by Geels and Schot (2007).

Guides by the California Department of Transportation

One of the findings of the 1988 California State telecommuting pilot program evaluation was that having telecommuting advocates within an organization or department— “champions”—was an important element for the success of a

telecommuting program (Nilles 1990). Support from senior management was also found to be an important factor (Nilles 1990). Jack Nilles—whose consulting firm JALA International helped plan, manage and evaluate the pilot study—authored that evaluation report, and its findings were influential. It was in part to address such challenges that the California Department of Transportation (DOT) in 1991 released two guides for telecommuting, one aimed broadly at employees of firms interested in telecommuting and one specifically at executives (Shirazi et al. 1991; Pratt et al 1991). The guides were prepared by the California-based nonprofit Commuter Transportation Services Inc. in collaboration with the California Department of Transportation, and funded with grants from the US Department of Transportation and Federal Highway Administration. One of the primary authors and two the contributing authors had been involved with Nilles in the original California State telecommuting pilot.

The more general of the guides, *Telecommuting: Moving the Work to the Workers: A Handbook to Help you Set up a Program at your Company* exhibits all four strategies to promote telecommuting. Firstly, despite framing its contents as "suggestions" and raising the option of less formal arrangements, the majority of the guide's materials are geared towards setting up selective and structured telecommuting programs (Shirazi et al. 1991, p. i). The guide provides three sample documents for formalizing structured arrangements, including a sample telecommuting policy, and sample agreement, and assignment forms that would be signed by participating telecommuters and which specify in detail rules and tasks (p. 48-55). The timelines for setting up a program covers seven stages including weeks for training of telecommuters and supervisors, and ending with an ongoing process of evaluation and troubleshooting.

In selecting participants in a telecommuting program it considers both the ideal qualities of telecommuters and their managers, noting, “not every employee, supervisor, or job is appropriate for telecommuting” (p. 15). Qualities of the “ideal” telecommuter read as a list of ideal workers generally, consisting of being exceptionally self-motivated, disciplined, productive, knowledgeable, and skilled (p. 16). The selection survey for telecommuters is four pages and collects quantitative and qualitative on job tasks, desire to telecommute, work habits, skills, and relationship with supervisor (p. 59-62).

The benefits of telecommuting are presented by the guides author’s in three sections: “What’s in it for your company”, “What’s in it for your employers”, and “Impacts on the community”; with the latter section on community as just one short succinct paragraph, and benefits for company and employees spelled out in multiple bullet points across multiple pages (Shirazi et al. 1991, p. 2-6). Stated company benefits are productivity gains, reduced absenteeism, employee satisfaction, lower overhead costs, but are contingent upon the telecommuting program being “well designed” (p. 2). Employee benefits are stated as avoiding traffic, saving money on commutes, and greater flexibility. The final strategy embodied in the guide is efforts to anticipate and address the concerns of management. According to the general guide, upper management is most concerned by the “bottom line” and are best convinced with evidence from successful programs such as those that show increased productivity, while middle managers are considered as the bigger challenge, in large part because the guide authors see telecommuting as requiring supervisors of telecommuters to “manage by results” rather than other means such as observing work hours (p. 7-8). The guide suggests starting with

open-minded volunteers among middle management and including them in the design of the program (p. 8).

Marketing by the Oregon Office of Energy Telework Team

Starting in the 1990's the Oregon Office of Energy offered material assistance to employers setting up telecommuting programs, in conjunction with administering a tax credit program that provided a form of protected space for doing so. The state's wide-ranging Business Energy Tax Credit would cover thirty five percent of telecommuting project costs over a period of five years, but projects had to be approved in advance by the Oregon Office of Energy's Telework Team ("Tax Credits for Telework Equipment" 1998). The Telework Team provided employers with access to two dozen documents about telecommuting in printed, electronic, or online formats, as well as three video guides ("Telework Tools" 1997). These materials exhibited all four of the telecommuting marketing strategies: encouraging selective and structured telecommuting, highlighting specific organizational benefits, and highlighting societal benefits, and anticipating management resistance.

Telecommuting was marketed to employers as being only suitable to "the right kind of worker" with "the right kind of job" and "the right home environment." A Teleworker Selection Guide provided by the office was designed to ensure that employees in telecommuting programs were self-motivated, organized, already successful in their job, and that their job was suitable for telecommuting, which included the "ability to define tasks and work products with measurable work activities and objectives" ("Teleworker Selection Guide" 1997). In a presentation given by the Telework team, managers were encouraged to err on the side of caution in selecting

teleworkers with the instruction “don’t let people telework you are unsure of”, and to start with a pilot program and carefully track results (“Telework: What’s in it for the Manager?” 1997).

But in advocating for telecommuting, the telework team made its case on the basis of both potential benefits for firms and societal benefits. They state that the Office of Energy promotes telework, “because it conserves fuel, relieves traffic congestion, and improves air quality -- and because it makes good business sense.” A wide variety of case studies of telecommuting being implemented in Oregon and elsewhere provide examples of specific measurable benefits, such as productivity gains and savings on parking space (“Case Studies of Successful Telework Programs” 1996). Yet while numerous potential benefits for the organization are offered, the societal benefits of telecommuting are put front and center in the model “Telecommuting Work Option Policy” that employers are encouraged to use, which opens with:

> *Traffic congestion, air quality and energy use are increasing. The measures employers take today directly impact the quality of life in our community and neighborhoods.* (“Sample Telecommuting Work Option Policy” 1996)

Finally, while the Business Energy Tax Credit was designed to incentivize upper management to develop telecommuting programs, concerns of managers were still considered to be a potential obstacle to telework adoption. To that end the office’s Telework Team offered by mail "The Manager's Telework Kit” which included a video and a booklet entitled *Manager's Quick and Easy Guide to Telework,* which sought to address the common concerns of managing teleworkers. Additionally, a presentation given by the Telework Team sought to present telework to middle managers as an

opportunity to be a more “innovative, progressive, and successful, manager,” pointing to the potential to have more satisfied and effective employees (“Telework: What’s in it for the Manager?” 1997). By 2001, the Oregon Office of Energy claimed to have assisted 504 organizations with telecommuting programs (Finlayson 2001). However, the Business Energy Tax Credit Program ultimately became controversial through its later support of large renewable energy projects, and was ended in 2012 (Sickinger 2014).

Events through Telecommute America ‘97

The 1990’s saw the formation of numerous local telework advocacy associations. Many were chapters of the national Telecommuting Advisory Council, which was founded in 1993 to promote telecommuting and govern chapters. By 1996 it was renamed "TAC - the International Telework Association" to reflect a shift beyond an advisory role as well as the existence of international chapters in Canada and Europe. The regional telecommuting advisory councils (TACs) were formed locally by coalitions of local firms, government agencies, and nonprofits. In 1997—arguably the peak year of telecommuting advocacy in the US—TAC listed 17 regional chapters (“Chapters” 1997). Other notable advocacy groups at the time included Smart Valley, which was founded by a coalition of Silicon Valley technology firms to apply network information services for the benefit of the community (“Welcome to Smart Valley” 1998), and the Telecommuting Association of Minnesota (TAM), which managed its own annual telecommuting conference (“Annual Conference” 1997).

The Telecommute America initiative brought together other local organizations to hold a biennial week of events along with a survey in 1995 and 1997 in order to promote the wider adoption of telecommuting. The founding members of Telecommute America

were the nonprofit Association for Commuter Transportation, AT&T, and three Federal agencies: GSA, EPA, and the Department of Commerce. Telecommute America '97 encouraged firms to "Discover a New Workplace" ("Telecommute America Week" 1997). The initiative partnered with local "teams"—associations, government agencies, and universities—in planning and hosting events in cities, including Smart Valley in the Bay Area, the USF Center for Transportation Research in Florida, and three local TACs: the Metro Atlanta Telecommuting Advisory Council, the New York Telecommuting Advisory Council, and the Mid Atlantic Telecommuting Advisory Council. The Telecommuting Association of Minnesota (TAM) was also a team in 1997.

Telecommute America '97 aimed to provide a large umbrella under which other advocates—including consultants and firms selling relevant technologies—could gather. It defined the concept of telework broadly as "alternate office arrangements" including home-based telecommuting, center-based telecommuting, and desk-sharing arrangements. Yet within this umbrella the same four strategies of telecommuting advocacy are apparent although in different proportions than in the previous examples reflecting a shift. The strategies of using selective, structured telecommuting programs and speaking to specific organizational benefits are most prominent. The other two strategies—speaking to societal benefits and anticipating resistance from management—are present but not as prominent in the contents of Telecommute '97 materials and events.

The national website asked firms to show support for Telecommute America Week by signing a pledge form and then to either publicize an existing telecommuting program, or to take steps towards starting a telecommuting program such as holding an

open house, forming a task force, or writing a telecommuting policy ("Telecommute America '97" 1997). Local events, which were managed by regional teams focused on providing organization with information that would help them with launching telecommuting programs designed to unlock specific organizational benefits. A half-day event in New Jersey hosted by Lucent technologies offered the "the Business Benefits Case" for telecommuting, while across the river an event at New York University's Stern School of Business guided interested firms towards "achieving strategic advantages through telework" ("New Jersey Association" 1997, "NYU/Fordham" 1997). A similar event in Boston also focused on the idea of applying telecommuting "as a strategic initiative." In Minnesota, sessions focused on "costs and benefits" and the "types of job functions" that are applicable for telecommuting, while in Silicon Valley telecommuting was considered as a type of "investment" ("Summary of Local" 1997).

While benefits to organizations from telecommuting programs figured prominently in events, benefits to society were not nearly as central. The employer pledge only mentions "improving the environment" as a benefit of telecommuting without going into the specifics of air quality or traffic congestion. Yet it does break out the organizational benefits of increasing productivity, decreasing overhead costs, flexibility for employees, and as a way to respond to disasters ("Telecommute America '97" 1997). Only one session focused on the benefit of not physically commuting, called "Keep the Job — Lose the Commute" and it was geared towards employees. Concerns about management resistance also do not appear as prominently as in the previous examples from Caltrans and Oregon, but they are present. One Telecommute America event in Cincinnati geared towards CEOs and managers considered "the effects of

telecommuting on managers" ("Summary of Local" 1997). Case studies of telecommuting management were part of a session in Minneapolis-St. Paul, and a session in Boston sought to address "manager's concerns" with telecommuting arrangements. ("Summary of Local" 1997). In addition to the four strategies, events also devoted some time to telecommuting technologies and their applications. Internet video conferencing technology was fairly new at the time and several took advantage to showcase its possible application for workplaces ("Summary of Local" 1997).

The localized telecommuting advocacy that fueled over 30 physical events in more than 20 localities at Telecommuting America '97 had declined by 1999. The national TAC, which had changed its name to the International Telework Advisory Council (ITAC), listed just four domestic chapters remaining in Arizona, the Mid-Atlantic, Atlanta, and New York ("Links to ITAC Chapters"). Telecommute America—renamed "Telework America"—became a project under ITAC, and in 1999 celebrated Telework America Day, which asked participants to work from home or a telework center on October 27th. Rather than host numerous local events, five local action summits were held, and Telework America hosted an online chat and provided guidance on setting up telecommuting programs through ten workshops posted on the ITAC website ("Telework America" 1999). AT&T and the GSA still partly supported the initiative, which included the survey, and added recommendations from an ITAC panel of experts ("Telework America" 1999). In 2005, the Human Resources association WorldAtWork acquired ITAC, a step that was approved by the ITAC board primarily because the "strong financial backing and staff resources" of WorldAtWork would better accomplish its goal of promoting telework ("Frequently Asked Questions WorldatWork" 2005).

Telecommuting—which once lived squarely outside of the standard practice of firms—had been adopted by an association that helps to govern these standard practices. Yet as the above examples of telecommuting advocacy show, this adoption was in a limited way that emphasized firm over societal benefit.

vi. Conclusions: The Long Groundwork for a Reconfiguration Pathway

The innovation of telecommuting began in a singular place with a study in Los Angeles funded by a National Science Foundation grant. Through its first decades advocates were grounded in the specific needs of the protected spaces and experiments that would provide the knowledge needed to locate a future where telecommuting resolved problems related to the daily commute by automobile. As such it provides a case of strategic niche management. But how much was telecommuting adopted as a practice during this period? In 1980 the level of full-time home-based work in the US was just 2.2% of the labor force, and less than 1% of the total US population. From 1980 to 1990, working from home fulltime increased by 0.7% of the labor force, representing an additional 1.2 million home-based workers. From 1990 to 2000, it increased by 0.3% of the labor force, representing an additional 800,000 home-based workers. And from 2000 to 2010 it increased by 1% of the labor force representing an additional 1.1 million home-based workers. Unfortunately data does not exist for these same time periods to show trends in part-time home-based work. An AT&T study quoted in 1984 found that 6% of the labor force did part-time work at home, but also reported that 7% worked at home full time—an inflated number compared to the Census. However in 2010 the Survey on Income Program Participation found that 9.5% of workers reported working from home either full or part time.

The regime layer for the socio-technical system of professional and administrative work location consists of workplace policies and norms, project/team structuring, and manager and employee attitudes about alternate work location (Table 1). While these trends in telecommuting adoption provide some evidence of a restructuring of this system, the extent of change appears small. Yet considering the case of telecommuting as a specific type of pathway to system change, and taking account of the role of pressure from the landscape layer, supports that the strategic niche management of telecommuting was not done in vain. Geels (2002) argue that niche innovations—"bottom-up"—are unlikely to alone bring about systemic change, and Geels and Schot (2007) offer a typology of pathways to system change that consider the interactions of the niche, regime and landscape levels in bringing about changes to systems. These pathways are: *transformation* due to pressure outside sources of power, *realignment* from problems within the regime with no clear solutions, *technological substitution* where niche innovations have matured to a point of viability, and *reconfiguration* where innovations are adopted piecemeal over time to solve specific problems. Of these four pathways, the nature of the adoption of telecommuting by the socio-technical system of professional and administrative work location fits that of *reconfiguration*, a pathway characterized by situations where radical innovations are adopted piecemeal as they develop select "symbiotic relations with the regime", and once embedded compete with existing practices to spur new innovations in a process that ultimately restructures the regime from within (Geels and Schot 2007).

In the three decades after the invention of the concept of telecommuting, its innovations were not mature enough to be widely substituted for office-located work, an

expectation that was shared among its planners. Through this period they advocated for the adoption of telecommuting in specific circumstances to unlock specific benefits for firms. This strategy resulted in a partial adoption of telecommuting innovations, as firms were guided towards implementing telecommuting in a limited "strategic" manner that downplayed environmental benefits. In a reconfiguration pathway, "regime actors explore new combinations between old and new elements and learn more about the novelties" (Geels and Schot 2007). The firms that employed telecommuting or flexible work location in strategic ways now compete with those that do not in both the marketplace and for skilled employees. This competition spurs more innovations with implications for work location, such as software packages enhancing remote team collaboration independent of physical location. These innovations serve to further promote telecommuting from home, but also connect to other work processes, such as enabling firms to assemble teams using personnel from multiple offices locations. This fits another characteristic of the reconfiguration pathway, an "interplay of multiple technologies." Yet innovation alone is challenged in driving systemic change. Which landscape factors, if any, exert pressure on this regime?

The landscape layer for the socio-technical system of professional and administrative work location consists of values related to home and workplace, urban form, transportation infrastructure, computing infrastructure, and economic conditions (Table 1). Of these, computing infrastructure—indicating the underlying infrastructure and conception of computing—appears a significant factor exerting pressure on the regime of professional and administrative work location. A shift in computing infrastructure from centralized computing to personal computing impacted the conception

of telecommuting and empowered the home office. Yet a more recent shift in computing infrastructure, from personal to mobile computing based on wireless broadband networks and cloud computing frameworks, is now exerting pressure. The pressure exerted by mobile cloud computing, which allows work to be done from nearly any location with data shared across devices, is occurring after telecommuting advocates established a foothold by seeing their niche innovations selectively adopted on the reconfiguration pathway. Other landscape pressures worth investigating in relation to work location are the values newer generations assign to workplace and home, and urban trends toward increased transit and cycling infrastructure. Also of concern is that efforts at the management of innovations are challenged by the continual reproduction of the social practices of daily life, which are thus hard to change (Shove and Walker 2010).

Where does this understanding of telecommuting as a managed niche innovation within a reconfiguration pathway leave telework planning and advocacy? Most local telecommuting advocacy groups dissolved in the late 1990s, and some national groups have also since ceased to be active. Neither victory nor defeat was ever declared. Telecommuting remains a standard option in transportation demand management, but its hopes are muted. Yet even so, more and more workers continue to report working from home and elsewhere. This chapter's findings give a positive, yet realistic, view of the historic role of telecommuting advocacy in initiating a reconfiguration pathway. Yet in advocating for a limited adoption of telecommuting, the original vision—that of being a solution to environmental problems related to the automobile journey to work—became sidelined. With some of its innovations adopted, and new pressure from a shift in computing infrastructure towards mobile cloud computing, it is time for new advocates to

remind regime actors of this important goal. Otherwise the transition that is taking place may not be towards greater sustainability.

Chapter 4: Telework and Computing Infrastructure: An Historical Perspective Across Centralized, Personal, and Mobile Cloud Computing

Telework—conducting work remotely supported by information and communication technologies—emerged in the United States in the 1970s, developed through the 1980s and took root in the 1990s. In this chapter I consider how shifts in the dominant computing infrastructure informed the representation of telework over this period. Through an historical analysis of primary and secondary sources I show how telework was first formed under centralized computing, but was shaped by the emergence and dominance of two other phases of computing infrastructure. Personal computing reframed the home as a space of self-entrepreneurship, and raised issues of the ownership and control of equipment used for teleworking for employees of firms. The adoption of portable personal computers was not transformative of telework, but did serve to strengthen representations of home-based telework even as it opened up other potential work locations such as hotels and vehicles. However in doing so it highlighted the technical challenges in gaining access to information across devices and locations, and contributed to work-life balance being seen as a key challenge of telework. Because it is still emerging, mobile cloud computing is explored through an historical analysis of email services. Mobile cloud email services are seen as supporting solutions to the technical problems of telework that emerged under personal computing, however further contribute to perceptions of the challenge of work-life balance.

Telework has been explored in the literature in relation to emerging information and communication technologies, with mobility of particular interest to the research community. In addition to home-based and remote office-based telework, Daniels (2001)

includes a category for “mobile telework” which includes consultants and vehicle-based workers who make use of mobile phones and laptop computers to communicate with clients and coworkers. Hislop and Axtell (2007) offer a three-dimensional pyramidal framework on which they chart workers against three location orientations: office, home, and the places in between. Garrett and Danzinger (2007) find that not only ICTs support the work style of these “flexiworkers”, but that type of contractual arrangement with employer is also an important factor in their flexibility. The notion of the “virtual office” first emerged in business practice but has been adopted by some researchers to describe the use of information technologies to expand “flexibility in the timing and location of work” (Hill et al. 1998). Messenger and Gschwind (2016) consider telework in three “generations”—home office, mobile office, and virtual office—with the latter being enabled through a cloud-based organization of work, and they frame this change from one era to the next as evolutionary rather than revolutionary. In this chapter I aim to add to the literature on telework by explicitly considering the role of computing infrastructure in relation to the representation of telework in a historical perspective from its earliest practice in the United States.

i. Methods and Sources

This paper bases its findings on an historical analysis of primary and secondary source materials from the time periods under study, which range from 1970 to the early 2000s. Source material includes marketing documents, newspaper articles, magazine articles, trade publications, mainstream books, and archived websites. Marketing materials included manuals, advertisements, and press releases from firms including Wang Laboratories, IBM, Apple, and Lotus. Newspaper sources included the *Wall Street*

Journal, the *Washington Post*, the *New York Times* and the *Los Angeles Times*. Magazine sources and trade publications include *Personal Computing*, *Family Computing*, *Byte*, and *LAN Times.* The Internet Archive project allowed the text of websites to be viewed at a particular point in time, and also provided online access to several magazine sources through its Computer Magazine Archives ("The Computer Magazine Archives" n.d.). Over 150 archival sources were analyzed however a smaller subset of those is referenced in this chapter. Finally, scholarly sources not only informed the framing of this chapter, but also served as secondary sources in providing contemporaneous material for analysis.

ii. Phases of Computing Infrastructure; Centralized, Personal, and Mobile Cloud

This chapter considers how three phases of computing infrastructure affected the representation of telework. While there is not a universally accepted typology of computing technology, this chapter is influenced by existing typologies in deciding its categories. King (1983) draws the distinction between "centralized computing" and "decentralized computing" based on not only hardware and network considerations, but also organization and managerial factors in firms. In a centralized arrangement, such as with a mainframe computer, computing capacity is managed within the organization at higher levels than in decentralized arrangements. Weiser and Brown (1996) more succinctly sum up centralized mainframe computing as "many people share a computer" compared to that of personal computing which they describe as "one computer, one person." More recently Voas and Zhang (2009) offer a five-category computing typology consisting of "mainframe", "personal", "network", "grid", and "cloud", in arguing that cloud computing in some respects represents a return to a mainframe arrangement with personal computers stepping back to an input terminal-like role. Finally, "mobile cloud

computing" has been stated as a category of computing infrastructure that combines aspects of mobile computing and cloud computing (Dinh et al. 2013). The types used by this chapter are: *centralized computing*, *personal computing*, and *mobile cloud computing*. While these categories are imperfect containers for a vast array of computer use configurations and contexts that existed in the years after 1970—with some blurring across category boundaries—their application gives insight into challenges and outcomes related to telework during this period. Each phase of computing infrastructure is briefly defined below.

Centralized Computing

The first phase of computing infrastructure, *centralized computing,* refers to mainframes as well as early limited-purpose workstations and word processors whose functions were limited and whose use was managed centrally in the organization. Before the 1970s large mainframe computers had been adapted to share processing time among multiple users within an organization through input terminals connected locally via serial ports or remotely—at lower speeds—through phone lines. Smaller minicomputers could also support access from multiple input terminals, or just one, and were more affordable, spurring adoption by smaller businesses (Klein 1977). Input terminal users could edit and submit commands to the computer, which then scheduled computing jobs for processing, and they could view output sent back by the computer (Hopgood and Prosser 1983). In 1976, there was great variety in the physical design of input terminals with some integrated into desks, others that merged keyboard and monitor into a single unit, and other with detached components (Atkinson 1998). As microchips became cheaper and more powerful, input terminals gained in processing power and memory, becoming

"intelligent terminals" that functioned as computers even as they could maintain connections to a central computer ("UTS 7000" 1976). Among the earliest standalone computer workstations were word processors, such as those introduced by Wang Laboratories in 1976 that incorporated a video display ("Wang Labs" 1976). Computer makers also designed more powerful "desktop microcomputers," yet even these were designed for connection to a shared organizational database ("Burroughs B22" 1982).

Personal Computing

The second phase of computing infrastructure, *personal computing,* indicates fully standalone desktop computers designed to serve a variety of functions for a single user, without necessitating a connection to a central computer or database, although this may be done optionally. The notion of a *personal* computer was predicted by as disparate figures as engineer Vannevar Bush in 1948 who imagined a "mechanized private file and library", and Stewart Brand, the counterculture founder of the *Whole Earth Catalog* who warned in 1972 that "ready or not, computers are coming to the people" (Isaacson 2014). Firms such as Apple, Commodore, Texas Instruments, and IBM began selling computers to individual home consumers between 1976 and 1981, and new popular magazines on the topic were founded such as *PC Magazine* in 1982, *Online Today* in 1982, *PC World* in 1983, and *Mac World* in 1984 that sought to educate the public about this new class of appliances and their uses. By 1990, companies that had focused on manufacturing workstation computers were entering the market for home personal computers ("PC and Workstation" 1989). And by 1995 nearly one third of US homes had a personal computer (Ziegler 1995). The emergence of portable personal computers enabled users to bring processing power into new contexts. The personal computer also advanced the merging

of audio and video capabilities with computing, introducing the possibility of a "mediated life" where human experiences are in part filtered through technology (Harrison 2009).

Mobile Cloud Computing

The third phase of computing infrastructure, *mobile cloud computing,* allows content and functionality to be more easily shared among stationary and portable devices by relying on remotely-located and distributed servers for computer processing, data, and file storage, accessed through the Internet, private or local network. Software, rather than being wholly executed on a local device, is delivered "as a service" through the network connection (Mell and Grance 2011). While dial up databases and bulletin boards such as *The Source* and *CompuServe Information Service* had offered home computer users access to content since before 1980, the development of the world wide web and user-friendly portals such as America OnLine (AOL) provided a "road to cyberspace" for millions of personal computer users in the 1990s (Mossberg 1995). The expansion of broadband and wireless networks enables a more constant quality connection to networks, giving users the benefit of what Kleinrock (1996) calls "nomadicity" in accessing cloud services and data. Through mobile cloud computing, mediated life is further extended beyond the desktop and into "on-the-street life" furthering the expanse of mediated living (Aoki et al. 2009).

iii. Origins of Telework in Centralized Computing

Telecommuting and Early Trials

The term "telecommuting" was coined in the early 1970s when offices were using centralized computer systems. Authorized employees used local or remote input terminals in their many design variations to interface with mainframes or minicomputers,

while others used early standalone workstations and word processors. It was in this context that Jack Nilles and colleagues at the University of Southern California first argued that employees working from centers located closer to their homes could help alleviate problems of traffic congestion derived from daily work commuting (Nilles 1976a, 1976b). Home, as a work location was not implemented in this earliest telework proposal, which collaborated closely with a case-study insurance firm and rather envisioned neighborhood-based work centers with clusters of computer terminals that communicated with a firm's central computer system (Nilles et al. 1976). All equipment for telework in the case study would be owned and supplied by the company. With terminals dependent upon a connection to a central computer at the firm, functionality would be largely limited to work-related tasks. Nilles notes the low cost and power usage of such unintelligent terminal units, using these figures as assumptions in the calculations he makes concerning the cost savings of having employees working from their homes (Nilles et al. 1976). While working from home was not part of the first telework study, a 1977 theoretical modeling of the substitution of telecommunications for travel imagines a computer terminal being installed in the worker's home dependent on the organization's central computer for its processing functions (Lopez and Gray 1977).

Centralized computing also contributed to conceptions of the types of work that were applicable for telecommuting. An early report by Paul Baran (1970), funded by the Department of Commerce, pointed to banking work as one area where computer mediated home work could succeed, also noting how working from home could be suitable for any worker whose office interactions with coworkers consisted of "routine matters." Baran (1970) also found what he called "secretarial" work such as taking

dictation to be potentially suitable for home, though he notes that "nonsecretarial duties such as getting coffee would of course suffer most by such an arrangement." Jack Nilles, referred to the types of occupations suitable for telecommuting as being part of the "information industry" including people who "move, manipulate, and/or transform information in some way or another" (Nilles 1976, Vicker 1981). He considered much of the clerical work in the insurance and banking industries to be in this category, and used workers from the service center and the underwriting division of a Los Angeles insurance firm as examples in his case study (Nilles et al. 1976). Telecommuting was also considered a way to give an opportunity to work for homebound individuals that might otherwise not have it. Two of the earliest home-based telecommuting programs (discussed below) were designed for disabled employees, while another included largely women with children working part time from home.

The earliest adoption of telework by firms included both center-based and home-based arrangements, with some workers using input terminals and word processors from home, and others making use of "satellite offices" to house terminals and teleworkers. Jobs at computer firms were among the first to be tested as telework arrangements largely through input terminals connected to central computers via a phone line and modem. In 1981 Control Data Corporation, one of the largest mainframe manufacturers, had 60 mostly programming employees working with terminal units from their homes (Vicker 1981). The firm also piloted a home-based vocational training and work program for disabled persons, and also offered an Alternative Work Sites (AWS) program for select employees to work from home or other office sites (Manning 1985). The company decided to not formally continue the AWS program but would leave employee work

location decisions up to the discretion of managers (Manning 1985). Other computer firms with early telework programs included Interactive Systems Corp. and CompuCorp, as well as Data General (McGlynn 1983, Vicker 1981).

Some large services firms, rich with clerical work, also tried out small telecommuting arrangements including Blue Cross Blue Shield, Chase Manhattan Bank, Aetna Life and Casualty, and the Continental Illinois National Bank and Trust Company (Pollack 1981, McGlynn 1983). Blue Cross/Blue Shield's "cottage keyer" program was designed from the ground up to make the most of home-based data entry of insurance claims. The mostly female workers paid to lease computer terminals for their homes and were part-time employees with no benefits, although most were wives of Blue Cross/Blue Shield managers who had full benefits (Geisler 1985). Claims were keyed into an input terminal connected to a mainframe at a central office, based on the original paper hardcopies (Pollack 1981). The program—though unusual in its participation of mostly wives of employees with children—was judged a success, with higher productivity rates than the in-office coders who benefitted from more advanced input terminals (Geisler 1985). The "secretarial" work, such as taking dictation, that Baran (1970) found to be suitable for home, was by 1981 being tested for telecommuting by Continental Illinois Bank (Vicker 1981). Also in 1982 American Express ran the experimental "Project Homebound" in which disabled employees at home received dictation via automated telephone audio, and typed into input terminals which transmitted them via a phone line to a printer in an office. Despite requiring the installation of multiple phone lines in the employee's home the project was judged a success (Raney 1985).

The Electronic Cottage

Also in this period when firms largely depended on terminal and workstation computing, Alvin Toffler published two influential books a decade apart, both filled with predications for the future organization of society. In *Future Shock* (1971) Toffler hints at a reorganization of work location stating that "human work will move out of the factory and mass office and into the community and home", but without providing much in the way of the details on the mechanisms. In *The Third Wave* (1980)—alongside a host of forecasts for a post-industrial society—he coined the term "electronic cottage." Toffler envisioned home as a place supported by and connected to the workplace through new computing technologies. He predicted, influenced by Nilles et al. (1976), that the costs of installing telecommunications equipment inside of homes, and connecting them to workplaces, would soon fall below the costs of gasoline and real estate, and that companies would soon widely adopt practices of "telecommuting" (Toffler 1980). Rather than see the presence of work in the home as detrimental to the welfare of children—as campaigners had viewed home-work at the turn of the century—he rather thought children would benefit from being exposed to work practices and that home-based work should even be integrated into their studies.

Toffler was aware, in 1980, of the personal computer and gave it some importance in his predictions as a future home appliance that could connect users with information services like *The Source*, a dial-up database providing information and media on a wide variety of topics. However he saw the role of the personal computer existing only "outside the confines of industry and government" (Toffler 1980). In his conception of work in the electronic cottage, firms would own the terminals and other equipment

needed to conduct work from people's home. However he does raise the potential of an alternative to such a model:

> *...if individuals came to own their own electronic terminals and equipment, purchased perhaps on credit, they would become, in effect, independent entrepreneurs rather than classical employees— meaning, as it were, increased ownership of the "means of production" by the worker. We might also see groups of home-workers organize themselves into small companies to contract for their services or, for that matter, unite in cooperatives that jointly own the machines.* (Toffler 1980)

While Toffler doesn't explicitly connect this thinking to new "personal" computer systems, others were ready to do so in their conceptions of telework, and his predictions and terminology were influential on those who embraced the notion of the computerized home-office.

iv. Telework Under Personal Computing

Working through Personal Computers

Personal home computing in the 1970s was considered the realm of hobbyists, distinct from the computer systems of large firms, which were dominated by centralized computing inf. A 1978 *Personal Computing* magazine article broaches the topic of making money with your personal computer but limits ideas to side projects such as publishing local supermarket price comparisons and horoscopes, or acting as a—presumably paid—secretary for your local bowling league (Fritz 1978). Using early personal computers often required knowledge in computer programming which was a barrier to its initial widespread adoption. For example a program in the BASIC language

for printing invoices published in 1979, points out its potential use for small businesses, but needed to be first coded into the computer, with the code customized for each invoicing scenario (Whitehead 1979).

Yet the personal computer quickly showed value for businesses—particularly small businesses that lacked the resources to invest in mainframes or minicomputers—with the development of software that provided useful functionalities without the need for a high level of computer expertise. In particular, the first spreadsheet program VisiCalc was considered a "killer app" for personal computers as commemorated on the wall of the Harvard classroom where it was first conceived in 1978 (Jacobs 2000). VisiCalc combined the problem-solving powers of "a calculator, pencil, and paper" enhanced with computer memory, and suggested that users could "learn the elementary features of VisiCalc in an hour" (Flystra and Mandis 1979). In 1982, it had sold an estimated 300,000 copies and was considered a "surprise hit" (Schrage 1982). By 1984, VisiCalc and newer software such as Lotus 1,2,3 were widely used for business tasks such as tracking sales performance, and calculating the value of inventory, and by 1985 the primary motivation for 60% of home PC purchases was for personal or business productivity (Sanger 1984, Mitchell 1986)

Larger firms also began to adopt personal computers in the early 1980s, which initially disrupted traditional centralized management of computing power in organizations. IBM's entry into the personal computer market in 1981, was seen as lending credibility to the new class of machines based on IBM's long history in computing (White 1982). Companies such as Aetna and E.F. Hutton reported departments buying personal computers under budgets labeled for "desks" and

"typewriters" to hide their computing purpose from management (Schrage 1983). Manufacturers of home personal computers soon recognized the office market, and Apple looked to the Lotus Office Suite Jazz on its Macintosh computers to help sales to firms (Miller and Larson 1985). In 1985, 78% of IBM PC sales and 34% Apple Macintosh sales were to offices (Miller and Larson 1985). By 1989, the personal computer and more powerful office workstation markets converged, as workstation manufacturers such as Sun Microsystems began making PCs for home use, and PC manufacturers such as Compaq sought to expand their presence in offices with more powerful PCs ("PC and Workstation" 1989).

The Home Office

Within this context in the 1980s, Toffler's vision of the "electronic cottage," in which conducting work from home was a key component, became mingled with notions of the increasingly useful personal computer. A 1982 book entitled *The Electronic Cottage* subtitled "Everyday living with your personal computer in the 1980s" (Deken 1982) points, though only briefly, to the potential of personal computers to connect via networks to the office. But communities by and for would-be teleworkers, both physical and virtual were inspired by Toffler's concept and the possibilities of "telecommuting", as well as the personal computer. A real estate development named "Eaglecrest," in Foresthill California on the outskirts of Sacramento, advertised itself in 1983 as an "electronic village" (McKinley 1985). Located far from the city center, the lots were embedded in a green, natural setting, being widely scattered in a heavily forested area (McKinley 1985). The house was wired with twelve phone lines which could be switched to ten locations throughout the house, allowing work to done from different locations,

including the office or even the kitchen, where—through a partnership with Apple—a Macintosh computer was a standard appliance (Perry 1985). However, this wired cottage was not nearly affordable for all—a mid-range Eaglecrest home, at $165,000, cost over twice the 1984 median US house price of $79,900 (McKinley 1985).

Practicing and aspiring teleworkers made greater use of new *online* spaces to share ideas about telework. The capability of computers to communicate by transmitting data over phone lines had existed for decades, but CompuServe, which had previously earned profits largely through contracts with organizations, launched a dial-in service for home users in 1979 ("CompuServe Begins New Service" 1979). This platform allowed users to communicate through bulletin board forums about topics of interests. Consultants Paul and Sarah Edwards founded both the *Association of Electronic Cottagers*, and, in 1983, the influential CompuServe "Working From Home" online forum, which existed for more than 30 subsequent years. The forum provided a place for the discussion of technical, financial, legal, and social challenges of home-based work, but also included many topics related to running home-based businesses.

The association of working from home with self-employment had already been strong, encompassing the doctors, lawyers and architects in private practices, music teachers and various home crafts manufacture mentioned as acceptable home-based work in many early zoning ordinances ("Zoning Regulation of Home Occupations" 1953). The use of a "home office" in the 1950s had been seen as serving these home occupations, or else was limited to personal matters such as correspondence and personal finance ("Home Office Should Be A Quiet Place" 1969, Ellingson 1970). The potentials of personal computing however helped reframed the home office as a site of entrepreneurship and

independence. The magazine *Family Computing* was founded in 1983, but ultimately shifted its focus entirely to the home office usages of personal computers. In 1987 it was renamed *Family and Home Computing* and in 1988 it was renamed *Home Office Computing,* while featuring a cover story entitled "The New American Dream: Working on Your Own" about "those who use computers and related technology to achieve their goals" (Sullivan 1988). As one 1994 book on setting up a home office puts it: "If you are the home office sort, you are probably the entrepreneurial type as well, and may be ready to head out on your own" (Berner 1994).

Many popular books in the 1990s sought to guide—and profit from—interest in home-office entrepreneurship. The website of Gil Gordon, a telework consultant lists over 30 books published in the 1990s that are guides to home offices and telecommuting (Gordon 2007a). Alongside examples of successful home-based entrepreneurship, tips, and motivation, they spelled out the bundle of technologies that were seen to support the entrepreneurial home office. The *Complete Work at Home Companion* was first published in 1990, and the 1994 edition marveled at the pace of technological change and price drops in just those 4 years observing that "working at home is a high tech venture, involving computers, fax machines, copiers, modems, voice mail, public databases, and other revolutionary developments in recent years" (Holtz 1994). Another reduces it to "seven basic items: a computer and printer, software relevant to your business, a fax machine, a desktop telephone and/or a cordless phone, and an answering system" (Parlapiano and Cobe 1996).

The home-based entrepreneurship enabled by the personal computer was also seen to open new ways of working particularly for women and parents. *The Woman's*

Work at Home Handbook published in 1986 predates the majority of popular books on the topic and sought to define "what the electronic cottage means to women." It focuses on starting and running home based businesses, providing examples of women who have successfully done so and a guide on the basics of personal computing (McConnel 1986). Running a home-based business was also seen in 1994 as a way for parents to spend more time with their children, although this balancing of work and home was also seen as a challenge (Shelenbarger 1994). One parent's statement about how her son is "picking up a good work ethic" by being exposed to her home office is reminiscent of Toffler's arguments for home-based work being ultimately beneficial for children. Another book is for aspiring "Mompreneurs," stating the advantages of home businesses for mothers as "family flexibility" and avoiding what the authors refer to being on the "mommy track" in corporate jobs, which limits promotions because of taking time off for parenting (Parlapiano and Cobe 1996).

Employee Telecommuting and the Personal Computer

The World Wide Web provided another means for those interested in telework to gather, including both entrepreneurs, and those interested in finding telecommuting jobs or encouraging their own employers to adopt telecommuting policies. Among the groups active online, the Independent Homeworkers Alliance launched its website in 1998, and provided information on classes in work-from-home personal computer skills such as medical transcription, as well as giving fee-paying members access to a remote work jobs database. ("Independent Homeworkers Alliance" 1999). Telecommute America—founded by the Association for Commuter Transportation, AT&T, and three federal agencies—was an advocacy organization active between 1995 and 1999 that encouraged

individuals and organizations to join a biennial event and survey to promote the adoption of telecommuting. Also available online was advice on setting up telecommuting programs, such as a guide produced by the Smart Valley Initiative, and a telecommuting FAQ provided by telecommuting consultant Gil Gordon ("Smart Valley" 1994, "Frequently Asked Questions" 1997).

Yet the enthusiasm shown by those who embraced the home office as a space of freedom and entrepreneurship was offset by managers at companies who were skeptical of the home-work arrangement for the employees that they supervised. Self-employed home workers were also seen as a different case altogether such that "most work at home types are self-employed and that's not the same as telecommuting" (Starfire 1987). In 1987 the Wall Street Journal reported that telecommuting was still an anomaly, and quoted a firm that decided to not continue with a work from home program because management "didn't feel like they could have a normal manager-employee relationship" (Ansberry 1987). One prominent voice in advocating for telecommuting, and particularly confronting the concerns of managers, was Gil Gordon, whose monthly newsletter, *Telecommuting Review: The Gordon Report* was published from 1984 through 1999, initially in print and then online. A large part of his consulting business focused on the problem of "getting support from management" for telecommuting, and he produced a video that depicts him convincing a skeptical manager that telecommuting can be implemented successfully (Gordon 1996, Gordon 2007b).

For firms with telework programs, the personal computer's adoption by homes and offices raised questions about the configuration and ownership of equipment used in telecommuting arrangements, and the late 1980s was a period of transition. In 1985 Blue

Cross/Cross Blue Shield thought that PCs installed in the homes of telecommuters would be paid for and managed by the firm.

> *As we convert from the very specialized machines we are now using to general purpose personal computers, specifically the IBM PC, as our vehicle for claims submission, and provisions are made for our cottage workers to purchase these machines at our cost, new rules will be established."* (Geisler 1985)

In 1988, a Washington Post article described telecommuting both in terms of using your own personal computer at home, but also connecting to a central computer, defining it as, "you use your personal computer as a remote link to your employer's office computer" (Starfire 1987). The evaluation of a 1989 telecommuting pilot program by the government of California, found that 83 percent of telecommuters owned their own homes computers, and preferred that over the option of having a state-owned computer installed in their home (Nilles 1990). Conflicts and confusion emerged during this liminal period. A dispute over the cost of setting up a home office to allow telework from home, led to one employee quitting his firm (Shelenbarger 1994). At AT&T, telecommuters had to negotiate with their managers about what equipment the company would pay for, except for sales staff who had customarily had all of their equipment paid for by the firm (Noble 1995). Additionally, the use of personal home computers for work purposes created questions on whether the cost of such equipment could be deducted on tax filings. However a Supreme Court ruling in 1993 determined that the computer could only be deducted if its primary purpose was work both in terms of numbers of use and types of use (Lewis 1993).

Challenges to the Early "Mobile" and "Virtual" Office

In the early 1980s, computer-supported work on-the-go was not a simple or seamless endeavor. Steven K. Roberts set out on a bicycle journey across America in 1984 to demonstrate how nomadic work was made possible for some workers in information professions by portable briefcase-sized computers and the capability of computers to connect to one another through telephone lines (Roberts 1984). While the technology existed for a showcase, it was far from seamless due to a scarcity of network connection points and storage limitations on portable devices. For Robert's system to function, he used a portable computer to access a larger computer installed at home or in an office, and a human assistant—which he referred to as a "uniface"—to help coordinate communications and file sharing (Roberts 1984).

Portable computers, such as the one carried by Roberts (1984) on his bicycle, were first widely available in the early 1980s. Byte Magazine, which reviewed 60 models in 1983, considered them in three categories: *pocket computers* that were handheld programmable calculators with minimal data storage and *briefcase computers* that were the bulkier precursor to modern laptop computers, and *transportable computers* which were full-sized mini or micro computers designed with a handle or other features in order to make them transportable (Wszola 1983). The portable market for briefcase computers had settled on the terms "laptop" and "notebook" in its marketing materials by 1990, with the latter loosely denoting smaller-sized versions, and in that year 14% of the global computer sales was in portable computers (Pollack 1990). The possibility of the portable computer as complete replacement for an office desktop (not just a supplement) also took hold in the early 1990s, with the release of more trouble-free devices with color displays (Lewis 1991). In 1994, Compute Magazine tested eleven new portables and declared that

despite being more expensive than desktops, “notebook computers have come of age” by overcoming problems in previous models with limited storage, processing, and battery life (Benford 1992).

The promise of portable personal computers as a tool for business, and in particular for use outside the office, was put forward in early marketing materials and advertisements. A manual for the Radio Shack TRS 80 Model 100 portable computer describes working outdoors:

> *I'm sitting here under a blue sky, listening to the birds and the wind, just me and my Model 100 Portable Computer. I can hear a car on the road below me, and above, the faint roar of a jet too distant to be seen. What a fine place to write a book. Or for that matter to figure out last week's expense account. Or to plan my schedule for the week ahead.* (Kellogg 1984)

GRiD Systems Corporation, in advertising another early portable computer targeted at the business market, relates a case where a meeting to negotiate a corporate takeover was decided by the presences of the GRiD Compass which was used to conduct a live analysis connection to a Dow Jones database (“The Computers Whirred” 1983). When Apple lunched its first Powerbook laptop in 1991 its double-paged magazine ad campaign featured both corporate business user list their the contents of their device—“notes for speeches”, “company budgets”—and also artistic users, such as musicians and authors (“What’s on your Powerbook” 1991). A year later, IBM declared of its Thinkpad in an ad targeting traveling executives that, “It’s what Shakespeare would have used on a flight to the coast” (“Introducing Thinkpad” 1992).

Prior to the availability of cellular mobile phones or portable personal computers, "mobile office" most often referred to a temporary facility in a mobile trailer, set up by government agencies, politicians, health care providers or firms to serve a geographic area far from their main office location. But in the late 1980 and early 1990s it was used to refer broadly to the notion that spaces outside of the office could be made locations of work because of ICTs. The first cellular mobile service, from Ameritech Cellular Communications, debuted in 1983, and others, such as from Bell Atlantic and other "Bell" firms, soon followed ("Cellular Mobile" 1983). Cars were among the first spaces referred to as mobile offices due to the growth of cellular car phones from the mid-1980s. For example by renting a car equipped with a car phone, business travelers now gained the ability to "step off a plane and into a car, and immediately start making business calls" (McArthur 1984).

"Mobile office" soon came to encompass a suite of technologies that included portable computers, cellular phones, fax machines, printers, and beepers, which allowed work to be conducted from a variety of locations outside the office, such as a car, home, a hotel, a boat, or an airport. A newspaper article in 1988 described the hypothetical "mobile office" functionality that firms were competing to offer as "a carry-around black box outfitted to provide phone, computer, facsimile, dictation, telephone answering, paging, electronic mail and a host of value-added connect services in a car, on a boat or in a backyard" (McArthur 1984). One such aspirant device (at least in part) was the short-lived 14 pound Wang "LapTop" computer which was designed for corporate sales forces and had a built-in printer tucked behind its full size keyboard ("Wang Labs" 1986). The concept of the "virtual office" emerged in the early 1990s and coexisted with the notion

of the “mobile office.” However its meaning was less associated with a specific space, such as a car, and more related to the freedom to telework of the individual, which was summed up by one interviewee as the notion that “we can be anywhere and run our company” (Keller 1993). For one advertising agency the goal of the virtual office program was to give the employees “free reign” to work where and when they wished (Patton 1993). Yet for firms the virtual office was also a strategy through which the costs of real estate could be managed through offloading some work to non-office locations (Matthews 1993).

Early adopters of these technologies and arrangements, included professions that spent time on site with clients such as salespeople, consultants, auditors, and real estate agents, with firms in some cases taking away their dedicated desk space in favor of shared desks (Pacelle 1993). Yet the “mobile office” and “virtual office” initially reinforced the more traditional practice of teleworking from home. Companies like IBM, which had not participated in the earliest wave of telecommuting trials, began issuing mobile phones and laptops to employees in 1993, and in 1995 had a “mobile office project manager” in one of its regional offices to oversee a program affecting 75% of its employees, yet much of this work was done at home (Pacelle 1993, Shelenbarger 1994). The virtual office for a saleswoman at ATT was primarily her home, where she worked before making visits on her sales route (Noble 1995). The telecommunications firm MCI launched a service called “HomeOffice Link” in 1993 that could route calls via an 800 number at times when the employees was working from home (“MCI Introduces” 1993). Finally a 1995 interview given by the editor of *Mobile Office Magazine*, which had been

founded in 1989, was largely about the topic of corporate office workers conducting work from home (Marchini 1995).

This focus on home as an alternate work location in part reflects the challenges of conducting telework on the go under personal computing. In the absence of the infrastructure to support an easy network connection for portable devices, particularly wireless Internet, which was not widely available until after 2000, would-be mobile workers encountered problems. Being a road warrior at the time meant contending with the dual technical challenges of finding a wired connection through which to connect to the Internet, and gaining access to necessary information across multiple devices and networks. A packing list for traveling with a laptop included a portable modem and the dial-in numbers of online services such as Compuserve or The Source (Levitan 1988). Not all hotels had the connectors that a modem would require, although for the dedicated that problem could be overcome by unscrewing the wall plate and using alligator clips provided by a "road warrior laptop kit" (Shannon 1989). And even at hotels where the phone could be accessed, dialing in to check email over the course of a multi-day stay could result in charges of hundreds of dollars due to hotel phone use fees (Bulkeley 1990). A second problem lay in the ease of access to information and functionality even where a wired network connection could be made. The role of fax transmission, dictaphones, and overnight mail in working on the road speaks to the limitations of what could be done with just a portable personal computer and a network connection (Librach 1993, Thomas 1990).

v. Telework Under Mobile Cloud Computing: The Case of Email

The final phase of computing infrastructure, mobile cloud computing, supported solutions for these technical challenges through wider access to the Internet and by enabling access to the same information and capabilities across computing contexts. But it also contributed to the challenge of life-work balance being seen as fundamental to telework. The term "cloud computing" was coined in 1996 at the offices of Compaq Computer, although it did not enter common industry usage until a decade later (Regalado 2011). However, the usage of processing power and data storage on remote systems predates the terminology. As Voas and Zhang (2009) have argued, the notion of cloud computing has distinct similarities to centralized computing, particularly in configurations using input terminals to connect to a timesharing mainframe computer.

An examination of the history of email adoption will illustrate the similarity between centralized and cloud computing and show the thread of transformation from one to the other that took place under the influence of personal computing. While web-based email, wherein the user accesses messages through an Internet browser, is considered by the National Institute of Standards and Technology (NIST) as a clear example of cloud computing in the form of software-as-a-service (SaaS), even from its origins, email services fit an NIST description of SaaS wherein "the consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities" (Mell and Grance 2011).

Origins to Groupware

Electronic mail functionality first emerged on centralized timesharing mainframe systems. Initially users could only communicate through files such as those addressed to

one other via a filename, until programmers at MIT developed a "MAIL" command in 1965 that allocated a private mailbox for each user of the timeshare system to which text messages could be sent (Vleck 2012). The firm Dialcom, founded in 1970, offered similar mainframe timesharing email functionality to corporations, which it integrated with other office systems. (Jones 1981). "Electronic mail" was still a broad concept in 1982 when a cover story in *Personal Computing* magazine predicted that personal computers were poised to bring email into the mainstream (Rothfeder 1982). However the earliest consumer commercial email services, such as The Source and Compuserve were also based partly on centralized computing infrastructure. An advertisement for a modem promised to "transform your PC into a terminal" and offered email as one of the benefits (Kaplan 1986). Users dialed into the "databanks" for a particular service from which they would access messages from other users of that service. By the early 1990s, the telecommunications firms AT&T and MCI were also offering commercial services that allowed users to send and receive emails by accessing remote servers through local "front end" software on their PCs (Mossberg 1993). And after the emergence of the Internet the email services provided by Internet service providers similarly maintained mailboxes on their own servers wherein "it sits at your Internet provider's mail server until you check your email and pick it up" (Musgrove 1999). The Internet's RFC 822 standard specified a common email address format allowed messages to be transmitted beyond the systems of a single service or provider (Crocker and Overall 1982).

For offices in the midst of a switch from centralized to decentralized personal computing, local area networks (LANs) brought new possibilities for intra-office email. The adoption of LANs at the time was driven by the benefits of having computers share

in peripheral devices such as printers and modems, and the ability of computers to communicate and share information with one another such as through email (Birenbaum 1993). By 1984, there were over 16,000 local office networks, of which 5000 were based on the Ethernet standard developed by Xerox (Kneale 1984). Corporate email services developed for LANs included cc:Mail, which relied on a central "post office" file server to and from which the local software could write and read messages ("cc:Mail for Macintosh" 1996). The notion of "groupware" emerged in the early 1990s to describe software that enabled collaboration across local networks of PCs, including email messaging (Wilke 1992). Even some ambitious home office users, such as a husband and wife team working in event planning, made use of local area networks and email systems at home (Schaper 1999).

Webmail

Web-based email service eliminates the local front-end software installed on a user's PC, instead requiring users to login to a website to access their messages. Among the major webmail services, Hotmail launched in 1996, Yahoo Mail in 1997, and Google launched its Gmail in 2004. Web-based email was initially seen as a solution to the problem of the lack of transferability in ISP and company email addresses because it was not tied to either Internet service or employment, but rather belonged to the user only (Pegoraro 1999). The firms Mail.com and USA.net made a business of providing webmail access capability to ISPs and online communities. USA.net raised 23 million in investment in 1998 with a large share coming from its client Netscape for whom it provided webmail functionality ("USA.net Completes" 1998). Bell Atlantic, Prodigy and Earthlink were among several ISPs that partnered with the webmail provider Mail.com to

allow customers to access their emails “whether they're on the road, at work, at a friend's house or in a cyber cafe” through a web interface (“Bell Atlantic.net ” 2000). By 2008 “logging on to Gmail or other email service had become a routine part of daily life, completed without a thought” (Stross 2008).

Novell and Lotus, two of the largest groupware email system makers serving corporate users added webmail functionality to their products in 1995 and 1995. (Dorshkind 1996). Network administrators were initially resistant to adopting webmail functionality on the grounds that they “can result in the most intimate details of your business transactions being stored on someone else's server as well as someone else's machine, unbeknownst to you” as email text data would be cached by the browsers of the day for non-secure connections (Dorshkind 1996). Yet some employees of the time were determined to have webmail functionality, and in its absence, some took to using personal Yahoo accounts while traveling to conduct business because they were easier to check remotely (Frangos 2001). Among a set of “email tips for the road warrior” in 2001 was a suggestion to forward Microsoft Outlook emails to Hotmail to access them while away from your office computer (Gomes 2001).

The advent of more secure webmail systems, such as Hewett Packard’s addition of Secure Sockets Layer (SSL)-enabled webmail to its corporate email platform OpenMail in 1999, alleviated some concern with webmail’s security (“Secure access” 1999). Network administrators grudgingly yet cautiously accepted their role as “the person who must make sure that email, database access, faxes and snail mail can be instantly and easily extended out to that pajama-clad Human Resources mid-level manager working from home twice a week” (Gaskin 1998). Smaller firms and self-

employed persons also embraced webmail. A lawyer giving technology advice to other lawyers in 2000, advised the use of a webmail platform and to use emails to track changes so that "everyone involved in the case will have instant access to the same information from the same source" (Bernstein 2000). In time, webmail service providers also sought to serve firms, supplanting the dominance of groupware email systems. Yahoo purchased Zimbra, a company that provided webmail services to firms, in part to compete with Google who had begun targeting smaller firms and universities with its Gmail service (Helft 2007).

Mobile Email Access

The earliest personal digital assistant (PDA) devices, such as the Apple Newton launched in 1992 and the Palm Pilot 1000 launched in 1996, did not support email access. However later devices took advantage of cellular Internet access and incorporated email as a core function. The first Blackberry device by Research in Motion (RIM) sought to provide the "wireless email solution" to the problem for users who "spend a significant amount of time away from their desk and are frustrated by their inability to stay connected to their email" ("Research in Motion" 1999). The device was designed to work with Microsoft Exchange email systems and for the enterprise version of the Blackberry. RIM's encrypted servers would relay messages between the mail server and mobile devices. Other services at the time also had email as a central feature such as the PageWriter pager from Motorola and the later version of Palm's handhelds that added support for Microsoft exchange email to compete with the Blackberry (Fixmer 1998, Kay 2002). Later versions of cellphones, designed for messaging and email also offered connectivity to Yahoo Mail and Gmail (Biggs 2007).

Compared to Roberts' 1984 bicycle journey, the situation for users of portable computers had improved considerably by the mid 1990s. Portable computers had processing power and data storage that allowed them to run the same operating systems and software in most cases as desktops, but in a much smaller frame. Yet, users still encountered one of Robert's key challenges: the need for a wired connection to be made in order to network with other systems. Cellular provided early wireless connectivity for users of portable computers via a small modem that could be plugged into the back of a laptop computer. Subscribers to Ricochet's cellular service were provided access to wireless Internet in select metropolitan areas that included Washington DC, Seattle, and San Francisco (Casey 1997). Ricochet was marketed towards college students, and workers that travelled within a region, such as salespeople, engineers, and real estate agents (Hardy 1996). But in 1997, the 802.11 working group within the Institute of Electrical and Electronics Engineers (IEEE) published the first standardized specification for wireless local area network (WLAN) (Kim and Lee 2015). "Wi-Fi", as the IEEE specification came to known commercially, began to proliferate from 1999.

Access to email was a seen as a fundamental reason for workers desiring wireless connectivity on a portable computer, such as for the "traveler who cannot be away from their email" (Tedeschi 2001). By 2003 the sight of laptop users congregating in a public space was a sign to such users that a Wi-Fi signal is available and that it could be a good spot to "catch up on email" for work (Tedeschi 2003). Hotels, airports, libraries, and some cafes, including "cybercafes" setup for the explicit purpose of Internet access, were among the early installers of WiFi hotspots (Tedeschi 2001). Additionally portable devices had come to support wireless access through cellular networks, WLAN, or both

such as in the Palm Tungsten C introduced in 2003 and the Blackberry 7270 launched in 2004, which were among the first mobile phones to have built-in WiFi capability (Soto 2003).

Alleviating Technical Problems

Seen through the example of email, mobile cloud computing brought together cellular network access, Wireless LAN, portable computing devices, and software as a service. In doing so it alleviated two major technical problems of telework that emerged under personal computing. Firstly, it alleviated the problem of needing a wired Internet connection, which limited the spaces from which email could be accessed, as under mobile cloud computing portable devices had come to support wireless access through cellular networks, WLAN, or both as has become the standard on newer smartphones. Secondly, it alleviated, in some configurations, the problem of being unable to easily access the same information across different devices, such as work emails that are only accessible on a work computer or behind a corporate network firewall.

Under mobile cloud computing the rational for the adoption of practices of telework now rests more on non-technical issues than technical ones. For example the notions of both the “mobile office” and the “virtual office” were seen as contributing to challenges of work-life balance. In enabling workers to be on call from nearly anywhere, they drew attention to ways technology and changes to work location affected the social lives of early adopter workers, both in the personal and professional realms. In the mid-1990s the term “road warrior” was used to describe not just traveling workers but particularly those who were willing to address problems in the middle of the night, or who would sneak time on family vacations to respond to colleagues about client matters

(Knox 1995). Personal spaces converted into an office, such as at home or vehicle was seen as a "crucible for work-family conflict" (Shellenberger 1995). Managers, such as a vice president at Compaq computer would even discourage employees from working excessively outside of business hours from home (Shellenberger 1994). Additionally, "life without the watercooler" was hard to give up for some employees who were reluctant to give up their desks upon the implementation of hot-desking schemes that encourage them to come to the office less frequently and use shared desk space arranged through a reservation system (Pacelle 1993). Wireless email access enabled through mobile cloud computing contributes to these concerns, and was described in 1997 as one "scary sign of the increasingly blurry line between work and personal time," and in 2000 as contributing to "the workday that never ends" (Ziegler 1997, Hafner 2000).

vi. Conclusions

In this chapter I have provided an historical analysis whose findings relate shifts in dominant computing infrastructure over time with representations of telework. Findings show that telework was forged in the era of the dominance of centralized computing under the banner of "telecommuting." The first hypothetical case study on telecommuting envisioned input terminals in regional suburban telecenters connecting to a central mainframe computer. The rise of personal computing from the realm of hobbyists to a dominant phase of computing in offices had three effects on the representation of telework. Firstly it fueled notions of the home-office as a space of self-entrepreneurship and independence. Secondly, it raised questions about the ownership of equipment used for telework done in the home as well as contributed to concerns among managers about the oversight of telework. Finally, the earliest portable personal

computers highlighted the technical challenges of needing a wired connection to gain access to networks, and an uneven access to information across different device contexts.

Because it is still emerging, mobile cloud computing infrastructure was explored in this chapter through the example of email services. Mobile cloud computing was seen as supporting solutions to the technical problems that emerged under personal computing by providing wireless access to networks, and access to the same information and services across device contexts. However in better enabling the "virtual office," it contributed to the concerns about work-life balance that first emerged with the availability of mobile phones and portable computers. Mobile cloud computing infrastructure and use is still unfolding, and individuals and organizations have adopted it for tasks beyond email communications. For example the online customer relationship management (CRM) platform Salesforce.com launched in 1999 and promised that users could "exploit the power of the Internet to access, manage and share all of your business' sales information" ("Online Sales Force Automation" 2000). The firm's revenues doubled every year up to 96 million for 2003, and after raising 110 million dollars in a public offering in 2004, there surpassed one billion dollars in revenue in 2009 (Rivlin 2004, "Salesforce Raises" 2004, Vance 2009). Such cloud platforms enable a greater amount of organizational information to be accessible online, expanding the number of workers and types of work that can be done from remote locations.

In addition to providing an historical record, this chapter's analysis suggests that the empirical survey and interview research into current practices of telework, such as what follows in the subsequent three chapters, benefits from being informed by an understanding of underlying computing infrastructure and how phases of infrastructure

have interacted with the representation of telework over time. Rather than treating ICT as either a “black box” or a collection of discrete innovations, it is more enlightening for researchers to give thought and voice to the underlying infrastructure through which organizations and individuals are practicing telework.

Chapter 5: Work Location and Travel in the United States 2003-2017: An Analysis of American Time Use Survey Data

The notion of commuting for work often assumes a neat division between a distant single workplace and home. Yet not all jobs take place entirely in a single workplace location. Truck drivers, house-cleaners, and traveling salesmen have long challenged this simple conception of work location, and telecommuting from one's home has been a viable option for some workers for decades. Additionally, recent advances in information and communication technology (ICT) may further diversify work locations though two mechanisms. Firstly the rise of mobile and cloud computing allow teleworkers to be better connected to colleagues, clients and work information from home, but also locations beyond the home such as cafés, and anywhere one can get a connection. Secondly, the growth of Internet technology firms that seek to coordinate the matching of consumers with delivered goods and services may affect the structure of employment in ways that shift work locations, such as towards vehicle-based work.

In this chapter I explore the relationship between work location and travel among US workers from 2003 to 2017 using data from the American Time Use Survey. In doing so, I seek to test and build upon recent findings using time use data in the Canadian context (Lachapelle et al. 2017), as well as explore new avenues related to this topic. I define four categories of alternate work location: working from one's own home, working from other people's homes, working from cafés/libraries, and working from vehicles, and construct a nominal variable that captures both single location and multiple location workers. Using this variable I test the relationship between work location and

duration of daily travel, and participation in morning and evening peak hour travel periods. Findings show that both working from home and working from vehicles grew as a percentage of total workers over the study period. Those working only from home on a workday spend less time traveling, while those working from vehicles or from multiple types of locations spend a larger amount of time traveling. Working from home increases the likelihood of avoiding peak hour travel, however the strength of this effect is dependent on the combinations of locations from which workers conduct work.

i. Background: Telework, Travel and Work Location

Does telework reduce the need for physical travel? As early as 1976, the person who coined the term "telecommuting" offered it as an alternative practice to the problems of traffic congestion derived from daily work commuting (Nilles et al. 1976). In an early 1988 study conducted in California, travel diary data was collected from state workers enrolled in a telecommuting program as well as from members of a control group; results showed an expected reduction in weekly work trips due to substituted work trips, but also a reduction in non-work trips by family members (Kitamura et al. 1990). A more recent study (Choo et al. 2005) used vehicle miles traveled (VMT) as the dependent variable rather than trips, as well as an aggregate national panel data set compiled from multiple sources spanning 1988 to 1999; it finds that telecommuting has a small negative effect on VMT. A 2010 meta-analysis (Andreev et al. 2010) considered 35 empirical studies of the effects of telework, and found that nearly all of them showed the relationship between telecommuting and travel to be one of substitution, in which telecommuting reduces travel. Despite these repeated empirical findings some doubt remains about the effects of teleworking on travel.

Mokhtarian (2002) argues that even if many short-term studies show a minor substitution effect, in the long term both telecommunications-based interactions and travel-based interactions will grow, yet telecommunications-based interactions will grow at a faster rate allowing it to take a larger share of interactions even as travel increases. Others similarly argue that the relationship between telecommunications and travel is a complex one requiring new concepts. The notion of *activity fragmentation* is offered by Helen Couclelis (2004) who argues that activities are now being spread across time and space in ways that they never could before ICTs and that this change is embedded in people's perceptions of action. In a special issue introduction, Schwanen at al. (2008) argue that the substitution/complementarity dichotomy represents a form of technological determinism, and that the specific contexts in which digital activities interact with physical ones must be considered.

Recent telecommuting research has strived for more complex modeling of telecommuting. Asgari and Jin (2015) add to traditional dimensions such as option, preference, choice, and frequency, the possibility of additional daily work-related trips for telecommuters that could contribute to a complementarity effect. Additionally, telecommuting may interact with residential location choice. Hu and He (2016) consider differences in the travel outcomes between part and full-time telecommuters, finding that those who telecommute less frequently tend to have longer trips to work than either those who telecommute more frequently or those who don't telecommute. Also of growing interest is the distinction between types of telecommuting based on time of day, duration, and interaction with work done at the workplace. Habbad et al. (2009) find that in the United Kingdom "part day" homeworking— defined as working from home in addition

to attending work on the same day—is more prevalent than full day homeworking among full-time workers, but that only full-day homeworking is associated with a belief that commuting is a struggle to be avoided. Deng at al. (2015) add "overtime" workers—defined as those who work from home while maintaining their regular commute patterns—to create a three-part categorization of home-based telecommuting. Asgari et al. (2016) additionally explore differences in departure times for different types of telecommuters. Lachapelle et al (2017) used Canadian time use data to explore the relationship of working from different locations with travel, finding that working from home was associated with less overall travel, a decreased likelihood of traveling at peak travel times, and an increased likelihood of using a non-motorized form of transport.

There are two recent innovations driving research in remote work. Firstly, Kleinrock (1996) noted that in the 1990s, being disconnected from a network was a more normal state than being connected and called for technological infrastructures to better support a lifestyle he called "nomadicity." Hardware technologies to address these challenges have developed in subsequent years, and now a patchwork framework enables mobile computing devices to access the Internet through 3G and 4G data networks and Wi-Fi hotspots. A second innovation stream is a cloud computing model in which software is provided "as a service" through the Internet (Mell and Grance 2011). A simple dichotomy of home and office may be inadequate to capture the routines of workers in this new context. For example, nomadic knowledge workers structure their work lives around projects, and both use and reshape the digital infrastructure of nomadicity as they traverse multiple spaces in service of the tasks and relations that comprise a day's tasks (Erickson et al. 2014). The broad category of "mobile workers"

include such nomadic workers, as well as those whose work necessitates changing locations or those for whom mobility is work, such as mobile hairstylists and vehicle drivers (Cohen 2010).

In this chapter I contribute to the existing literature by creating knowledge about three aspects of the relationship between work location and travel in the United States. Firstly, empirical research has focused largely on remote working from home only. Here I will additionally explore working from locations such as café's, vehicles and other people's homes, which may be either conducted or arranged through ICTs. Secondly, while much past research has largely considered full-time and full-day telecommuting, this chapter's analysis allows for the inclusion of multiple work locations in a single day, thus including part-day telecommuting in order to contribute to that important growing body of research. Finally, in addition to looking at total travel duration, this research considers the relationship of work location with both peak hour travel and initial departure times in part to inform demand management and peak hour avoidance policies. In doing so it supports an application of telecommuting knowledge as a policy tool to be applied in specific contexts for specific purposes, rather than as a panacea for all travel-related problems.

ii. Data and Methodologies

For all analyses in this chapter I use data from the American Time Use Survey (ATUS) conducted by the Census Bureau on behalf of the Bureau of Labor Statistics (BLS). This annual cross-sectional survey was first conducted in 2003, and seeks to shed light on the amount of time Americans spend doing various activities by asking respondents about the 24 hours prior to a telephone interview. The unit of analysis for

ATUS is a 24-hour period for members of selected households that participate in the Current Population Survey. These households are originally selected using a multistage stratified sampling strategy. ATUS observations are weighted to ensure that final estimates demographically reflect the US population, and to adjust for the oversampling of weekend days.

A primary shortcoming of the ATUS is that it only allows respondents to report doing one activity at a time. A respondent who dined with friends has to choose between reporting such an activity as "eating/drinking" or as "socializing," but could not report both. Similarly a respondent who composes and sends a work email while watching TV cannot report that activity as both "work" and "leisure/relaxing." An additional problem is that the notion of "workplace" in the survey is subjective since a server or cook might consider a particular restaurant to be their "workplace", whereas a salesperson might conduct work at that same location and report it as "restaurant or bar." Regarding those who work from vehicles, it is uncertain whether a truck driver would report the truck vehicle itself as a "workplace" or as a "car, truck or motorcycle." The same question could be asked of taxi or "e-hail" drivers. Most troubling is the potential for uncertainty to lead to measurement error as different interviewers have different solutions to lack of clarity. While such concerns should be borne in mind, they are more likely to contribute to error than to bias the sample in a way that would undermine analysis.

Using pooled data from 2003 to 2017 and limiting the study to employed individuals who conducted work on the diary day, there are 44,470 cases in the dataset used for analysis. I create work location summary variables indicating whether an individual worked at a given location on the diary day, and the time and duration they

worked at that location. These locations include workplace, own home, other person's home, café/library, vehicle, or unspecified. These variables alone do not constitute a mutually exclusive nominal categorical variable, since individuals may work from multiple locations in a single day, such as the combination of workplace and home. Therefore a single nominal work location variable is constructed that accounts for both those who worked from a single location and those who worked from different combinations of multiple locations.

The variable for total daily travel time sums all time periods when the respondent indicated they were traveling by any mode. Work-related travel includes time spent commuting and time spent working in a vehicle, although this may erroneously include times when the vehicle is parked or stopped, which is not specified by the survey. The study also creates a measurement of participation in peak hour travel. While the choice of whether or not to participate in peak hour travel on a given day is highly constrained, the enabling of remote work through the capabilities of ICT can loosen these constraints to the extent that firms and occupational requirements allow it. For the purpose of this analysis peak travel times are defined as being 6AM to 9AM in the morning and 4PM to 7PM in the evening, although other levels were tried yielding similar findings. Each case of a US worker on a workday is tagged as having traveled during these peak times or not during that day. The final nominal peak participation variable indicates whether an individual traveled at peak times in both the morning and evening, in the morning only, in the evening only, or during neither peak travel time.

After an analysis of alternate work location prevalence and trends, I analyze the relationship between measures of work location with both daily travel duration and peak

hour travel, using firstly, two negative binomial models with daily minutes of work-related and total travel time as dependent variables, and secondly, a multinomial logistic regression model with peak travel participation as the dependent variable. The independent variables in all models are nominal workplace location, along with employment, family, demographic, locational and time characteristics (Table 2). The year variable was tried as both a continuous trend variable and as year-specific dummies to loosen the linear assumption of a time trend, though only the former is reported in the results. Weekend days were excluded from the models. While this study's goal for assessing relationships is in part exploratory, expected findings are that home-based working is associated with decreased overall travel, and a decreased likelihood of participation in peak hour travel. The peak hour model is augmented with a descriptive analysis of initial departure times for workers who conduct some or all work at home. The levels of measurement for all variables included in all analyses are shown in Table 1.

TABLE 2: Measurement of Variables Included in Analyses

	Variable	**Measurement**
Daily travel time	Total travel time	Ratio
	Work-related travel time	Ratio
Peak travel	Peak travel participation	Nominal
	Peak travel morning and evening, Peak travel morning only Peak travel evening only, No peak travel	
Departure time	Departure hour from home	Ratio
Work locations	Work locations	Nominal
	Home only, Other home only, Café/library only, Vehicle only, Unspecified only, Workplace and home only, Workplace and other home only, Workplace and café/library only, Workplace and vehicle only, Workplace and unspecified only, Workplace and 2 or more, Home not workplace and 1 or more	
Employment characteristics	Is part time worker	Binary
	Is self employed	Binary
	Is paid hourly	Binary
	Occupation	Nominal
	Industry	Nominal
	Education Level	Ordinal
Family & demographic	Is married	Binary
	Number of children	Ratio
	Family income	Ordinal
	Is female	Binary
	Race	Nominal

Locational and time	Age in years	Ordinal
	In metro area	Binary
	Day of the week	Nominal
	State	Nominal
	Year	Interval

iii. Results

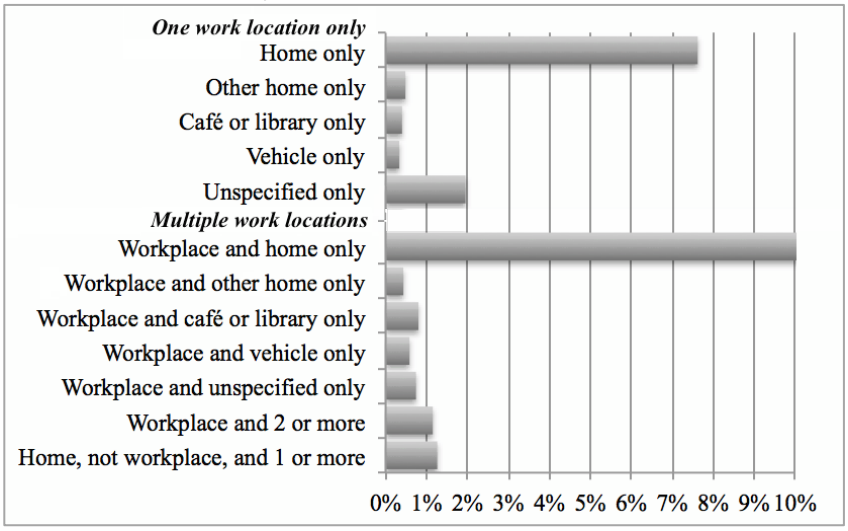
Results are presented in four sections below. The first section describes the prevalence of working from locations other than the workplace during the study period, as well as year-to-year trends for work location, travel duration and participation in peak hour travel. The second section presents the results of the travel duration linear regression models. The third section presents the results from the peak hour travel participation multinomial logistic regression models, and the final section augments this with an analysis of initial departure times to shed light on a mechanism of morning peak hour avoidance related to home-based work.

Prevalence and Trends

More than one-quarter of US workers on a workday worked from a location other than just their workplace during the study period. Figure 1 shows all the categories of the nominal work location variable except for the largest category of "workplace only" which accounted for 74.2% of workers. Of the remaining 25.8%, 10.8% percent worked from a single type of location—own home, other home(s), café/library, or unspecified. The remaining 15% worked from a combination of types of these locations and their workplace. For both one-location workers and multiple-location workers, the most prevalent categories involve homeworking, with 7.6% working from their own home only (full-day homeworkers), and 10.1% working from their own home and their workplace on a workday (part-day homeworkers). It is also notable that 1.3% of workers worked from their own homes and one or more non-workplace locations. The

"unspecified" categories are assumed to be largely those who are working from offices other than their own office, such as auditors, consultants, or equipment repairman.

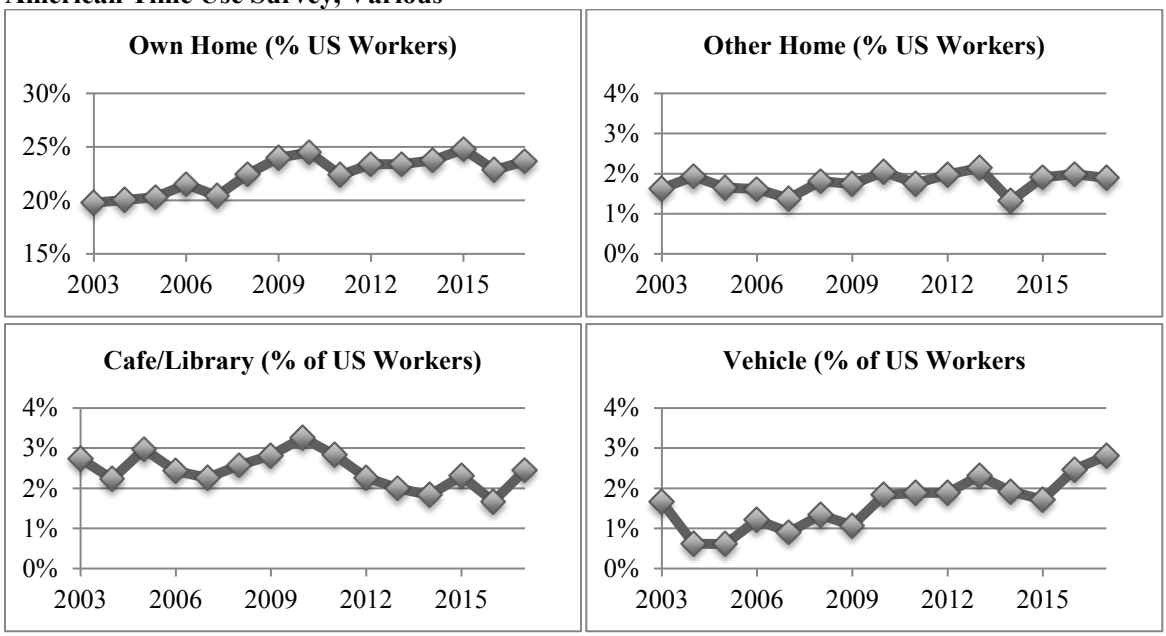
FIGURE 1: Alternate Locations of Work 2003 to 2017 (US Workers on Workday, n=44,470); Source: American Time Use Survey, Various



Note: Base category "Workplace only" is excluded and accounts for 74.2% of US workers on workday

Trends in alternate work location across the four known categories are shown in Figure 2 below, based on whether an individual worked from each location on the diary day, and regardless of where else they worked on that day. Working at home shows a clear upward trend from a low of 19.8% in 2003 to 23.7% in 2017, with a peak of 24.8% in 2015. Working from vehicles also appear to show an upward trend from 0.6% in 2004 to a high of 2.8% in 2017, though with a higher level of variability, which may be due to problems of measurement error as discussed in the previous section. In particular a sharp drop between 2003 and 2004 is inconsistent with the overall upward trend. The trends in working from other people's homes and from cafés/libraries are less apparent with a sharp drop from 2013 to 2014 in the former, and the latter seeming to show a downward trend from 2010 to 2014.

FIGURE 2: Trends in Alternate Work Location (US Workers on Workday, n=44,470); Source: American Time Use Survey, Various



There are statistically significant differences in the mean characteristics of those who work from alternate work locations compared to the general population of US workers over the study period (Table 3). In terms of gender, more women work from other homes, while more men work from cafes/libraries, and from vehicles. Self-employment is strongly represented among all four types of alternate work location. In terms of education, a larger percent of those working from home and from cafés/libraries have a bachelor's degree or higher, while a larger percent of those working from vehicles have an associate's degree. A larger number of own home workers have a family income greater than $100K compared to the general population of workers, while the opposite is true of those that work in other people's homes. In terms of occupations, those who work from own home or cafés/libraries are more likely to have a "management and professional" occupation. "Personal care and service" is overrepresented among those who work at other people's homes, and, not surprisingly, "transportation and material

moving" is over represented among vehicle-based workers, though not by as much as was expected.

TABLE 3: Means of Selected Variables by Work Location Participation (US Workers on Workday 2003-2017)

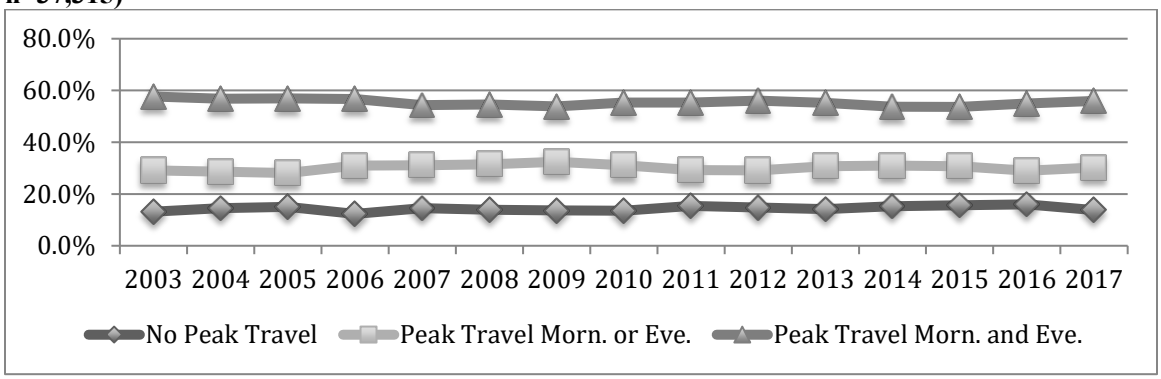
	All Workers (n=44,470)	**Own home** (n=9,525)	**Other home** (n=697)	**Café/library** (n=1,046)	**Vehicles** (n=678)
Is female	0.447	0.457	0.542***	0.389***	0.352***
Age in years	41.0	43.2***	41.1	40.1	41.7
Is self-employed	0.100	0.252***	0.292***	0.228***	0.192***
Has multiple jobs	0.056	0.084***	0.123***	0.082**	0.079
Has col. degree or higher	0.376	0.587***	0.388	0.479***	0.343*
Has fam. income > $100K	0.226	0.334***	0.19*	0.261**	0.247
Occupation:					
Mgmt. and professional	0.121	0.193***	0.103	0.202***	0.137
Personal care and service	0.029	0.035***	0.091**	0.050	0.0453
Trans. and mat. moving	0.056	0.025***	0.041	0.033***	0.203***

*Stars indicate significance of t-test: * p<0.10; ** p<0.05; ***p<0.01; Source: American Time Use Survey 2003-2017*

Daily travel time remained steady during the study period, although there is a slight upward movement after 2014 for both work-related and total daily travel time, which rose to highs of 48.8 minutes and 87.2 minutes respectively in 2017 (Figure 3). Peak hour travel among US workers on a workday changed only slightly over the study period. In figure 4 the nominal variable is depicted but with one peak period-only (AM or PM) travelers compressed into a single category. The percentage of workers who participated in peak hour travel in both the morning and evening declined from a high of 57.7% in 2003 to a low of 53.8% in 2014 but rose back to 56% in 2017. This downward trend is somewhat balanced by the upward trend in those who engaged in no peak hour travel which rose from 13.2% in 2003 to 15.3% in 2014 but then declined to 13.8% in 2017. There is no clear trend in the combined category of those who travelled in the morning only or in the evening only.

FIGURE 3: Trends in Mean Daily Travel Time (US Workers on Workday, n=37,315)

FIGURE 4: Trends in Peak Hour Travel Participation (Percentage US Workers on Workday, n=37,315)



Model: Work Location and Minutes of Daily Travel

The first set of models seeks to explain daily travel duration through work location, while controlling for charcteristics of employment, family, demographic, location, and day of the week. Diagnostic tests showed no multicollinearity, however an examination of residuals shows that the normality assumption of ordinary least squares (OLS) would be violated if that model were applied. Additionally both dependent variables were shown to be overdispersed. As such a negative binomial regression model was chosen over a Poisson regression model. Table 4 presents results for one model that uses daily work-related travel time (including time spent commuting) as its dependent variable, and a second model using total daily travel time (regardless of purpose) as its dependent variable. Negative binomial coefficients indicate the change in the difference in the logs

of expected counts of the dependent variable for a unit change in the independent variable. However they can be converted to incidence rate ratios, which in turn can be used to speak to percentage change. For the first model, the coefficient for working only at home of -2.63, indicates that daily travel is associated with a decrease in work-related travel time by 93 percent, compared to the base category of workplace only, which is not surprising since home based workers may not be engaging in a commute at all. The coefficient for working only from a vehicle of 2.45 indicates an increase in work-related travel time of over 1000 percent, which is again not surprising because time spent working in a vehicle, such as driving a taxi, is also included as work-related travel. It is also notable that working from multiple types of locations tends to increase work-related travel time, with the exception that working from a workplace and home in the same day is predicted to have no effect on work-related travel times.

In the model for all travel time, the work location categories show similar results to the first model. The coefficient for working only at home of -0.39, indicates that daily travel is associated with a reduced total daily travel time by 32 percent, while the coefficient for working only from a vehicle of 2.01 is associated with an increase in travel time of 647 percent. Working from multiple types of locations again tends to increase travel with the exception of the combination of workplace and home, for which according to the coefficient of -0.035, there is a predicted slight decease of 3.4 percent in total travel time. Working from home and other non-workplace locations in the same day is predicted to increase total daily travel in both models. Day of the week is only significant to total travel time, with Fridays associated with a 12 percent increase in total travel time according to the coefficient of 0.114. Among the control variables for both full models,

which are shown in the appendix, higher incomes and living in a metropolitan area are associated with increased daily travel time, while more rural states like Kansas, North Dakota and South Dakota, as well as working in the agriculture industry, are associated with less travel time.

Model: Work Location and Peak Hour Travel

Results for the multinomial logistic regression on peak hour travel participation are shown in Table 5 for the independent variable of interest, nominal work location. Results for the full model, including control variables are available in the appendix. As expected, working only from home on a workday greatly increases the likelihood that a worker will not participate in peak hour travel, or only participate in one period of peak hour travel in a day. Someone working from home only is over 38 times more likely to engage in no peak hour travel than someone working from their workplace only and over 16 times more likely to participate only in the evening commute. Working from other non-workplace work locations only also increases the likelihood of no peak hour travel or peak hour travel in the evening only, but no effect is found for morning only peak hour travel. Someone working from a vehicle only on a workday is over five times more likely to engage in no peak hour travel, and over three times more likely to engage in peak hour travel in the evening only, than someone who works from their workplace only.

Part-day homeworkers who attend the workplace on the same day are only slightly more likely to engage in one period of peak travel in a day only—morning or evening—with a stronger effect for the latter. Their odds of traveling during the evening peak while avoiding the morning peak increases by 27% for part day homeworkers who also attend their workplace, while the odds of traveling during the morning peak while

TABLE 4: Daily Travel Time in Minutes (US Workers on Workday 2003-2017; n=36,176)

	Work-Related Daily Travel Time				***Total Daily Travel Time***			
	Coef.	Std. Err.	t	Sig.	Coef.	Std. Err.	t	Sig.
Work Locations								
Base: Workplace Only								
Home only (n=3,538)	-2.63	0.13	-20.43	***	-0.39	0.03	-11.24	***
Other home only (n=213)	-0.24	0.10	-2.31	**	0.12	0.08	1.54	
Café/library only (n=168)	-0.17	0.11	-1.50		0.31	0.07	4.42	***
Vehicle only (n=128)	2.45	0.07	36.22	***	2.01	0.05	37.90	***
Unspecified (n=875)	0.17	0.06	2.82	***	0.37	0.05	7.98	***
Workplace and home only (n=4813)	0.03	0.02	1.51		-0.03	0.01	-2.41	**
Workplace and other home only (n=192)	0.20	0.08	2.45	**	0.17	0.07	2.40	**
Workplace and café/library only (n=367)	0.33	0.05	6.51	***	0.19	0.04	4.61	***
Workplace and vehicle only (n=244)	1.37	0.07	18.85	***	0.97	0.06	16.13	***
Workplace and unspecified only (n=403)	0.38	0.05	7.17	***	0.35	0.05	7.44	***
Workplace and 2 or more (n=578)	0.67	0.06	11.55	***	0.44	0.04	10.33	***
Home, not work and 1 or more (n=583)	0.82	0.11	7.73	***	0.72	0.07	10.28	***
Day of Week								
Base: Wednesday								
Monday	0.00	0.02	-0.07		-0.03	0.01	-1.88	*
Tuesday	0.03	0.02	1.23		0.00	0.01	0.06	
Thursday	0.00	0.02	-0.08		-0.01	0.01	-0.36	
Friday	-0.03	0.02	-1.28		0.11	0.01	7.72	***
Pseudo R-squared	0.0303				0.0128			

*Control variables not shown are included in appendix; Stars indicate significance: * p<0.10; ** p<0.05; ***p<0.01;*

TABLE 5: Odds Ratios for Peak Hour Travel Outcome (US Workers on Workday 2003-2017; n=36,176)

(Base: Peak Morning and Evening)	*No Peak Travel*			*Peak Morning Only*			*Peak Evening Only*		
	Odds	t	Sig.	Odds	t	Sig.	Odds	t	Sig.
Work Locations									
Base: Workplace Only									
Home only (n=3,538)	38.96	38.23	***	3.62	11.22	***	16.97	30.29	***
Other home only (n=213)	2.65	3.06	***	1.21	0.64		3.20	4.24	***
Café/library only (n=168)	3.95	3.98	***	1.20	0.43		3.64	3.62	***
Vehicle only (n=128)	3.13	2.99	***	1.23	0.47		2.67	2.66	***
Unspecified (n=875)	1.69	2.74	***	0.99	-0.07		2.25	5.26	***
Workplace and home only (n=4813)	1.13	1.33		1.18	2.37	**	1.21	2.61	***
Workplace and other home only (n=192)	0.99	-0.03		0.46	-2.30	**	1.74	1.95	*
Workplace and café/library only (n=367)	0.85	-0.63		0.91	-0.40		1.07	0.27	
Workplace and vehicle only (n=244)	1.52	1.48		1.09	0.31		1.94	2.60	***
Workplace and unspecified only (n=403)	0.58	-1.86	*	0.75	-1.34		0.77	-1.14	
Workplace and 2 or more (n=578)	0.57	-1.93	*	0.85	-0.67		1.94	3.55	***
Home, not work and 1 or more (n=583)	5.41	7.43	***	2.14	3.34	***	5.45	9.01	***
Day of Week									
Base: Wednesday									
Monday	1.06	0.88		1.08	1.27		0.99	-0.16	
Tuesday	0.98	-0.30		1.01	0.11		1.00	0.07	
Thursday	1.00	0.02		1.02	0.27		1.06	0.94	
Friday	0.96	-0.59		0.94	-0.92		1.13	1.91	*

*Pseudo R-Square=.0995; Control variables not shown but included; Stars indicate significance: * p<0.10; ** p<0.05; ***p<0.01;*

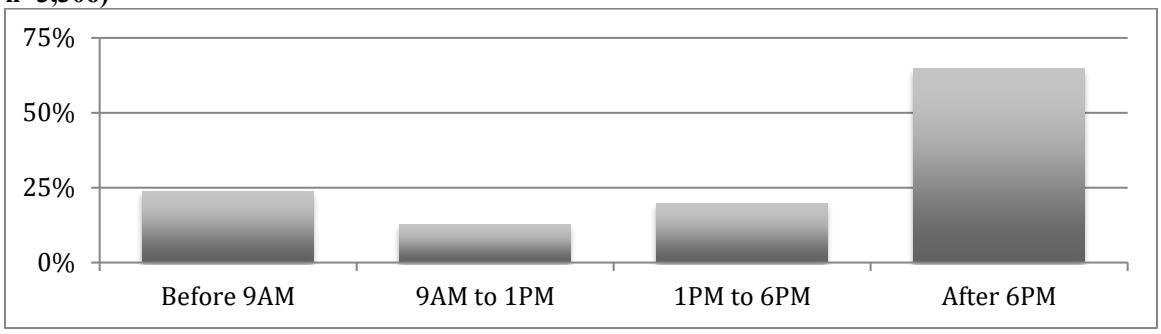
avoiding the evening peak increases by 25%. A last category of interest is those working from home in addition to other non-workplace locations, such as a home-based worker who goes out to work at a client's office or a café. Results show that they are over five times more likely to engage in no peak hour travel, and over five times more likely to engage only in peak hour evening travel, but only twice as likely to participate in peak hour morning travel only. Overall, those working from alternate locations seem more likely to avoid peak hour morning travel than to avoid peak hour evening travel. Day of the week does not have a highly significant relationship with participation in peak hour travel according to the model.

4.3 Homeworking and Departure Hour

The final analysis looks at the extent to which homeworkers may use work location to avoid peak hour morning commuting. In the model just presented homeworkers are shown as more likely to engage in just one period of peak hour travel (morning or evening) over engaging in both morning and evening peak hour travel, with a slightly greater likelihood of avoiding morning peak hour commutes. Other categories of work location also show an orientation towards greater likelihood of avoiding morning peaks. The following descriptive analysis seeks to show how homeworkers—in particular part-day homeworkers—offset their departures in a way that results in avoiding morning peak hour travel. Relevant to this question are the times of day during which part day homeworkers who also attend their workplace, conduct work (Figure 4). The largest category by far is after 6PM (65%), suggesting that most part day homeworkers are conducting work at home after they have already completed their evening commute, perhaps in an overtime capacity. However the second largest category is early morning

(24%), which could indicate a strategy of delaying departure to avoid or minimize exposure to the peak hour morning commute.

FIGURE 5: Times of Homeworking for Part Day Homeworkers (US Workers on Workday, n=3,306)

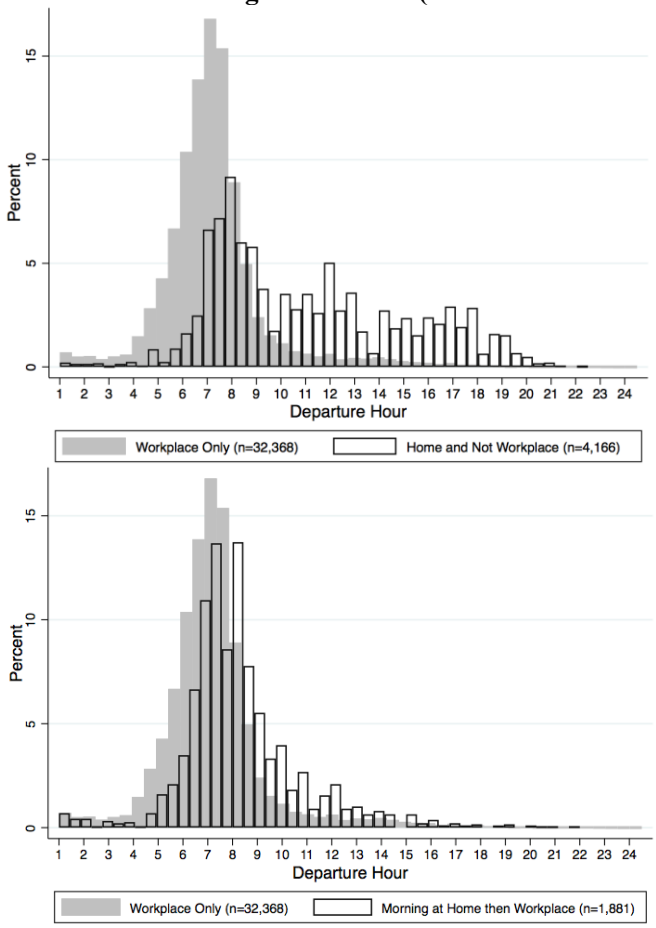


To shed light on this mechanism, two overlay composites of histograms compare the initial daily departure times of workers who only conducted work at their workplace to both home-based workers that did not attend a workplace, and to workers who worked at home in the morning and then attended their workplace (Figure 6). All three distributions are approximately normal but with a positive skew. Firstly, in the comparison of workplace-only workers with home-based workers that did not attend a workplace, the departure time of the home-based workers is clearly flatter and shifted to the right of the distribution for workplace only workers (Figure 6—left graph). The mean departure hour for workplace only workers is 7:14AM with a standard deviation of 133 minutes, whereas the mean departure hour for home-based workers that did not attend a workplace is 11:16AM with a standard deviation of 237 minutes.

Secondly, in the comparison of workplace-only workers with workers who worked at home in the morning and then attended their workplace, the distributions are much more closely aligned with similar peaking (Figure 6—right graph). However the distribution for workers who worked at home in the morning and then attended their

workplace is shifted slightly to the right of that of workplace-only workers indicating later departure times. The mean departure hour for workers who worked at home in the morning and then attended their workplace is 8:20AM with a standard deviation of 146 minutes. Those who do some work at home in the mornings before attending work leave on average one hour and 6 minutes later than workplace-only workers, closer to the end of the peak congestion period.

FIGURE 6: Departure Times and Morning Peak Travel (US Workers on Workday)



iv. Findings

Over one quarter of American workers on a workday conduct work from one or more alternate work locations, such as homes, vehicles, cafés, and combinations of such locations with their workplace. In this study I have shown, confirming previous findings

from the Canadian context (Lachapelle et al. 2017), that alternate work location practices matter to travel outcomes and deserve a place in policy making and demand forecasting. The major findings of this study, based on data from the American Time Use Survey spanning 2003 to 2017 are as follows:

Work location affects peak hour travel demand

Findings show that work location has a strong effect on peak hour travel. Full-day homeworkers are more likely to avoid peak hour travel in the morning only, evening only, or at both times on a workday. Part-day homeworkers are more likely to avoid traveling in either the morning or the evening peak travel period on a workday. Other work location practices such as café working, working from other homes, and working from vehicles, is also associated with avoiding peak hour travel. When we combine homeworking with other non-workplace locations, such as someone who works at home in the morning and goes to a café to work later in the day, the higher likelihood of avoidance of at least some peak hour travel periods remains.

Morning peaks are more affected by work location than evening peaks

Those who work from alternate locations are more likely to avoid peak hour travel in the morning than in the evening. With homeworking being the largest category of alternate work location, the analysis points to a mechanism of shifted morning departure times. Both part-day homeworkers who conduct work in the morning, and full-day homeworkers are seen as shifting their departure times to later times within or after peak hours. Additionally many of the other categories of both single-location and multiple-location work, showed strong or significant effects for avoiding peak hour morning travel but not for avoiding peak hour evening travel.

Only full-day homeworking is associated with less total daily travel

Findings show that working from home-only on a workday is predicted to decrease work-related travel time by 93 percent and daily total travel time by 32 percent. This difference could suggest that home-only workers augment their daily travel with trips that are beneficial for their welfare such as running errands or for recreation. Working at home and attending the workplace on the same day is also predicted to decrease daily total travel time perhaps due to the efficiency gained from some avoidance of peak travel periods, but only by 3.4 percent. All other work locations and combinations of work locations are predicted to increase total daily travel time. Working from vehicles is predicted to greatly increase daily time spent traveling, based on the imperfect assumption that vehicle-based work is comprised of traveling.

Working from home and working from vehicles are growing in the US

Homeworking is on the rise in the United States. The upward trend appears for both those who only work from home, and for those who work from home and work from one or more other locations. The associations of homeworking with the highest level of education, and with management and professional occupations suggest that homeworking is related to information and communication technologies. Vehicle-based working also appears to be on the rise, however as noted there are some concerns about its measurement. While evidence does not exist in this analysis to connect this rise in vehicle-based work to information and communication technologies, it may be related to the growing role of e-commerce and other delivery based services, as well as the rise of e-hail firms as a potential source of this growth, though more research into this area is needed.

Chapter 6: Remote Work in the New York Metropolitan Area Interview Results: Mobile Cloud Computing and Telework Decision-Making

The effects of telework on travel demand in a region are dependent not only on the extent, but also the nature of its adoption. The capabilities of information and communication technology (ICT), including new computing infrastructure modes such as mobile and cloud computing, both enable new job tasks to be done remotely, and influence telework decision-making by shaping perceptions of the workplace and relationships among it participants. In this chapter I present an inductive model of telework decision-making based on thirty-one qualitative interviews with workers in the New York metropolitan area who conduct at least some work remotely for their jobs using information and communication technology. After a review of the relevant literature, I describe the sample and the method of analysis that yields its inductive model of telework decision-making. Findings first relate interviewee experiences with each of the four contextual factors that set the stage for day-of decision-making: the use of team collaboration technologies, attitude towards commute and time spent commuting, understanding of the allowance of remote work, and perceptions of productivity and distraction. A subsequent section describes the specific factors that come into play on or around the day-of decision, which include errands & chores, parenting, weather, illness, congestion, vacation, and a desire for change of scene. In the conclusion of the dissertation, I argue based on this chapter's conceptual model, for the potential role of targeted incentives built on cloud computing platforms to encourage remote work as a means of managing travel demand.

i. Background: Telework, Travel, And Computing Infrastructure

Telework—the practice of using information and communication technologies to conduct work from a remote location outside the workplace—emerged in the 1970s as the concept of "telecommuting." Through a case study of an insurance company in the Los Angeles region, Nilles et al. (1976) demonstrated how employees with suitable "information" jobs working from centers located close to their homes, could save money and contribute to reduced energy usage and traffic congestion. The 1989 State of California Telecommuting Pilot Project, in which selected state employees conducted work from their homes, showed a reduction in both work trips for program participants and non-work trips for family members compared against a non-telecommuting control group (Kitamura et al. 1990). The 1990 Puget Sound Telecommuting Demonstration Project included both home-based teleworkers and center-based teleworkers and found that telecommuting reduced both daily trips and VMT (Henderson et al. 1996). Most subsequent studies of telecommuting programs have found that telecommuting can reduce travel (Andreev et al. 2010). While research has shown that transportation system benefits are achievable for telework programs, the factors that influence its adoption by employees and firms are complex.

Researchers have made efforts to understand the decision-making process of both employees and employers in relation to telework. Mokhtarian and Salomon (1994) presented a conceptual model that views the decision as derived from constraining factors, facilitating factors, and driving factors. Facilitating or constraining factors are related to having (or not having) a job suitable for telecommuting, organization support, awareness of the capability to telecommute, or access to the technology to do so. Driving

factors point to motivations based on a desire for independence, being more productive, not having to commute, having leisure time, or wanting to be more environmentally conscious (Mokhtarian and Salomon 1994). The authors operationalize this model with surveys finding that commute time, perceived stress, and a desire for independence are among the significant drivers, while distractions at home and missing out on workplace socialization are among the significant constraints (Mokhtarian and Salomon 1997). Bernardino (2017) used surveys with both employers and employees as the basis for models of their respective telework decision-making processes, with employers assumed to implement telecommuting programs where it gains them profit, and employees assumed to want benefits from reduced costs, such as from commuting, and benefits from improvements to lifestyle. Among numerous findings, Bernardino (2017) shows that telecommuters working on teams perceive more benefits from telecommuting than those working on individual tasks.

Researchers have considered the specific challenges of professional isolation and work life balance for teleworkers. Professional isolation was reported to be a problem because informal or spontaneous opportunities for socialization are often missed when teleworking, such as the networking that occurs around the water cooler, and informal learning during cubicle gatherings (Cooper and Kurland 2002). Interviews from a 1998 study of telework at IBM shows that a lack of these same activities resulted in a negative perception of teamwork, and also found negative feelings of blurred boundaries between work and home (Hill et al. 1998). Telework can improve productivity for some workers in some contexts, such as the 1980 case of Blue Cross/Blue Shield employees program in which teleworkers made 50% fewer errors (“Work from home by computer” 1987).

However a 1989 meta-study found that productivity was not significantly changed among home workers compared to in-office workers, yet managers preferred to have workers in the office (Olson 1989). Westfall (2004) argues that the failure of telework to be more widely adopted as evidence of its negligible effect on productivity, since economic logic dictates its adoption in the face of even relatively small real gains. An empirical study on the determinants of teleworking productivity showed that it was the existence of an internal method of evaluating teleworking outcomes that was most important to both productivity and to home-based employee satisfaction with teleworking (Hartman et al 1991).

In its earliest incarnations, information and communication technology was seen to largely determine which jobs *could* be done remotely. For example the ability of centralized computing to manipulate, store and retrieve information opened up the possibility of telecommuting for "information industry" jobs in the 1970s (Nilles et al. 1976). Researchers have since engaged in a deeper exploration of the role of computing technologies in telework, which now include consideration for mobile and cloud computing modes of infrastructure. Hislop and Axtell (2007) include consideration for mobile teleworkers, such as consultants and service repairmen, and offer a three-dimensional pyramidal framework on which we can chart workers against three location orientations: office, home, and the places in between. Such a framework creates a place for self-employed home-based consultants who may travel frequently to visit clients but don't have a local office to which they report. Alexander et al. (2010) consider how ICTs contribute to a fragmentation of work activities through the analysis of a survey showing the spatial and temporal distribution of activities like emailing, participating in meetings,

and web-based work. Messenger and Gschwind (2016) define three "generations" of telework practice in relation to technology—home office, mobile office, and virtual office—with the virtual office being supported through a cloud-based organization of work. In a cloud computing model, software, rather than being installed and executed on a local computer, is provided "as a service" through a network connection (Mell and Grance 2011). The category of "mobile cloud computing" combines aspects of mobile computing consisting of portable devices such as smartphones and laptops, and cloud computing, consisting of software and storage being delivered as a service (Dinh et al. 2013).

The literature on virtual teams examines how information and communication technologies support workers in collaborating remotely. The practice of virtual teams is enabled not only by technological change but also by changes to organizational structure and worker preferences towards flexibility, which create needs for workers collaborating on projects to have less frequent face-to-face interactions, and to accomplish more remotely. Yet it does not displace physical interactions entirely. Maznevski and Chudoba (2000) studied teams of decision-makers who were distributed globally, and found that their occasional physical meetings supported their virtual interactions in setting an agenda for what should be done. Mobile email access has been a focus of some studies. Mazmanian (2013) found that access to email on mobile devices gives virtual team members a perception of control and flexibility in their role on projects, however it had a negative effect on work-life balance. A mismatch in access creates challenges for those who lack access, as in the case of a group within a team asked to collaborate on a project that lack access to mobile email (Loeschner 2017). The social aspect of mobile cloud

computing platforms is also of interest to researchers. Social technologies, such as email, online forums, wikis, blogs, messaging, and social networks enable access to both expert knowledge and the experts themselves, and also provide opportunities for socializing within virtual teams (Jaharri and Sawyer 2012). Virtual teams also connects to a broader concept in the literature of the adoption of project-based work by organizations (Cicmil and Hodgeson 2006).

ii. Data And Methodology

This paper is based on a qualitative analysis of the transcripts of thirty-one in-depth interviews conducted in June and July of 2018 in the New York City "tri-state" metropolitan area. This qualitative research study employed a non-probability purposive sampling method, which sought out workers who had done at least some work remotely for their jobs with a computer or smartphone within two months prior to the interview. All interviewees were at least 18 years of age, employed, and resided in New Jersey, Connecticut, or New York state. Recruitment was done by email through the author's own professional networks based on his previous employment at advertising, technology and nonprofit organizations, as well as through Craigslist posts, and advertisements on the Reddit social media platform. Twenty-nine of the interviews were conducted using Skype audio: respondents booked half-hour time slots using an online booking system, and provided their phone number or Skype usernames and were called at the appointed time. The other two interviews were conducted in person. All interviewees consented to have the interviews recorded, which the author transcribed. Interview transcripts were coded for themes using the qualitative analysis software package NVivo. The analysis identified ninety-nine themes that drew from multiple cases. Using an inductive strategy

in which theory is constructed directly from the observations, this study presents a model of decision-making that includes four broad context factors which frame more immediate day-of decision factors. A primary shortcoming of qualitative research is that it often depends on non-probability sampling, as such this paper's model is not representative of telework decision-making nationally, and only represents this sample of workers in the NY-NJ-CT tri-state region.

The goal of this project is to study telework decision-making related to information technology-enabled remote work practices within the mode-rich New York City region. As such the interviewees are a diverse group from this area. There are seventeen men and fourteen women in the study. In terms of age, fourteen interviewees are in their twenties, nine are in their thirties, just one is in his forties, and five are in their fifties, while the remaining two declined to state their age. Twenty-two interviewees worked for a company with a local office or a local coworking space from which they conducted at least some work, while nine used their home as a primary workplace while working for themselves or for firms in other regions. Fifteen of the interviewees either own a car or have access to a car, and—in a metropolitan are rich with train service—thirteen interviewees use a train as part of their commute.

In order to maintain anonymity but also present the qualitative data in a relatable and effective way, pseudonyms will be used in conveying the experiences of interviewees in the findings section. Interviewees were encouraged not to mention company names, and these were excluded from transcripts and results, however in some cases the researcher knows this information. Product names, such as software platforms used by

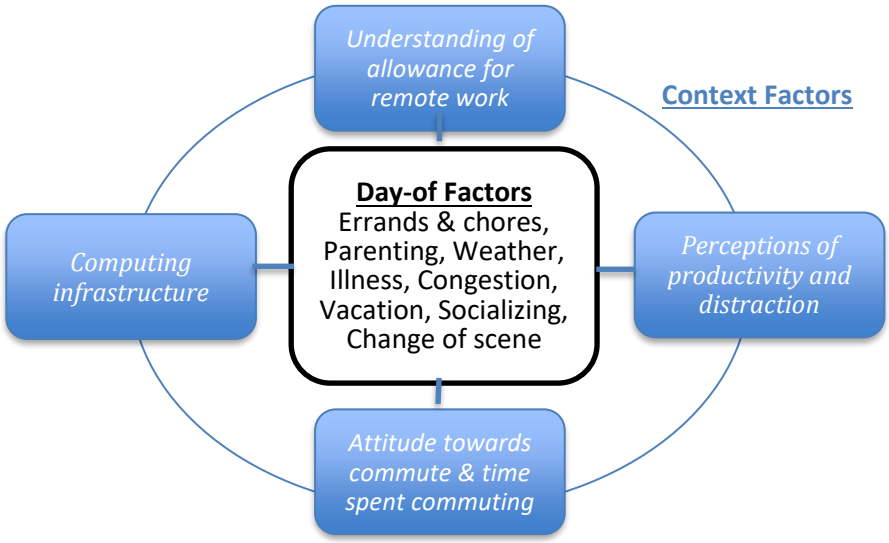
interviewees and their firms are considered important to the project, and are included except in cases where it may compromise the anonymity of the interviewee.

This chapter's study adds to the literature on telework decision-making, the growing body of work on the relationship between computing and telework, particularly for project-based work among virtual teams, by building an inductive model of telework decision-making that accounts for the use of cloud computing team collaboration platforms, which emerged as key theme in the interviews. Additionally, situating the study in the New York metropolitan area, where transit service is widespread and bike share schemes are growing, gives some insight into the practice of remote work and work location flexibility in a multi-modal region.

iii. Results

An inductive thematic analysis of the transcripts of interviews conducted with thirty-one employed adults in the New York metropolitan area who do at least some work remotely, yielded a model of telework decision-making (Figure 7). The model includes contextual factors that set the stage for day-of decision-making, as well as specific factors that come into play on or around the day-of decision. Contextual factors are: the use of team collaboration technologies, attitude towards commute and time spent commuting, understanding of the allowance for remote work, and perceptions of productivity and distraction. Specific day-of factors include errands & chores, parenting, weather, illness, congestion, vacation, and a desire for change of scene.

FIGURE 7. Inductive Model of Telework Decision-Making in NYC Metro



Computing Infrastructure: Mobile Cloud Computing Platforms for Team Collaboration

The most prominent theme to emerge from the analysis was the use of team collaboration platforms to access work materials and to communicate with colleagues and clients, particularly among younger interviewees working for firms. Such platforms exist through mobile cloud computing that allow processing to be delivered as a service through the Internet. Of the thirty-one interviewees, twenty four discussed one or more mobile cloud computing platforms: twelve referred specifically to using messaging platforms often across multiple devices, ten mentioned accessing shared databases through the Internet or working directly through company websites, nine referred to using video and audio conferencing platforms, five interviewees mentioned the Internet document-sharing and collaboration capabilities of online platforms, and three discussed online project management platforms.

Messaging platforms allow groups of coworkers to communicate remotely, and to have these messages accessible across multiple devices. The messaging platforms

discussed by interviewees included Slack, Microsoft Teams, Skype for Business, Google Hangouts, and the encrypted service Signal. Slack, which was the most commonly mentioned platform was described by one interviewee as "a way to organize the communication of different groups." Skype was the most commonly mentioned audio and video conferencing platform, with Zoom being the only other dedicated conferencing platform that was discussed, although interviewees did mention built-in conferencing functionality in Slack and Microsoft Teams. In terms of document sharing, interviewees discussed Google Docs, Google Shared Drive, and Microsoft OneNote. Project management platforms discussed included Wrike, Asada, and Version 1, and the flexible customer relationship management platform Salesforce.com. Many of these platforms offer more than just a single function. For example, while Slack's primary function is "team messaging", it incorporates conference calling and file sharing, as well as offering integration with other platforms including Skype and Salesforce. Finally, several interviewees talked about conducting work through the websites of their employers. This included systems for inputting medical records, data entry for education, and a custom remote education platform.

For workers at larger firms, mobile cloud platforms don't just come into play when the employee is working remotely from home, but rather they function in all contexts both because they are perceived to bring value even to in-office work processes, but also because frequently someone is "remote" even if just from a different office location. James is an analyst in his 30s who works one fixed day at home per week. He states that because his company has offices in multiple states, "when we do have face-to-face there's always somebody that's remote" with the result that "the work is pretty much

the same engagement with one another whether I'm at home or I'm at work." Similarly, Patricia, an event planner in her 20s describes her firm, which has offices in multiple cities and some remote-only employees, as "very much an online kind of thing." She uses Slack to communicate with a team that is located "all over the country," and she considers the Internet as "the easy way to stay connected and to communicate with my team." She works from home on average once or twice a week and has a commute of over one hour consisting of two trains. Louis perceives the flexible communication enabled by a suite of tools including Slack, Outlook, Skype, and an in-house personnel app, as necessary given the interdependencies between the systems he helps develop as a software engineer at a large firm with multiple offices. These diverse tools enable a quick solution for developers on different teams and in different cities in the event that "you're working on some software application and it's breaking my app."

Mobile cloud platforms also play a role in maintaining a social connection with colleagues regardless of physical proximity. Kelly, an engineer in her 20s who works from home occasionally—and is encouraged to do so when sick—contrasted the internal use of a document-sharing platform with a messaging platform, saying that the messaging platform was a more informal environment where "sometimes we send funny messages," and also where you could inform team members of your whereabouts, such as messaging "hey guys I'm in the lab today feel free to come look." Rose lives with three roommates and works in the music industry. She and most of her coworkers are in their 20s, and they use both texting and Slack for messaging one another. But she didn't initially realize one consequence of messaging as a cloud service where messages are held on a central server and accessed by multiple output devices: that "your head boss can read your Slack

messages" which she considered to be "a weird little privacy thing." But even with this drawback she appreciates that "when you do work from home, you can still be a part of everyone's conversations and their projects if they need help with something." Only one of the interviewees who collaborated with colleagues using mobile cloud platforms—a freelancer working for two startup firms—considered loneliness to be a problem, and one which she solved by working from cafes or voluntarily going into the office for the day.

Having "all those same tools on my phone," as Dana, a freelancer puts it, makes the smartphone an essential part of remote working for some of the interviewees who use mobile cloud platforms. Douglas works for a consulting firm, and bases his work schedule and location largely on "client needs." While working remotely, whether at home, on site with a client, or on the go, he relies on the Salesforce.com customer relationship management platform to keep him up to date on tasks related to his clients. He jokes that Salesforce.com, which he uses on his work-provided smartphone, "pretty much does my job for me." Simon, a parent living in the suburbs who works remotely from home full-time for a firm outside the US, notes how their project management software platform is available on his smartphone and says that the phone "becomes a part of you essentially, more so than if you were just working in an office." Michael, who works in the office one day a week and the other four from home, values that he can "keep up with any conversations through Slack on my phone" regardless of his location. John who works at an insurance company and is a parent, pointed out that his use of the smartphone was related to the status of his projects, stating that "right now we have a big project going on so I've been having to do that to make sure I'm on top of things."

For the workers that participated in this study, cloud computing team collaboration platforms, in which data and functionality are stored on remote servers and accessed across multiple devices and multiple users, are a normal part of the workday. With remote colleagues and client in other regions, the use of such platforms is not merely an exception made to accommodate a colleague working from home, but a normal part of businesses, because of the distributed nature of teams and clients. And messaging applications, such as the most popular option, Slack, can be more important to team and client communication than email. The only factor related to technology that acted as a deterrent to remote work was having a better "setup" at the office, as four interviewees mentioned "bigger monitors", "a really big screen", and even "two big screens" as something they miss while working from home.

Attitude Towards Commute and Time Spent Commuting: Commute as a Waste of Time

Among the twenty-two interviewees who traveled to an office at least some of the time in their current jobs, none had a positive view of their time spent commuting, and many were decidedly negative. This is particularly true of those with longer commutes, who also spoke in the same breath to the activities that replaced that commute time. Michael, whose office is in Manhattan about an hour and a half train ride away from where he lives with his parents, is well aware of the "3 to 4 hours traveling," and considers how "now I have better sleep and I actually start work earlier" as a result of not engaging in that commute. Douglas, the consultant, sees benefits for his personal life in the saved time stating "just the commute time alone which is an hour and a half to two hours [...] that additional two hours per day I can spend with the family, with my friends, and everything." Antonio's commute consists of a drive, a ferry ride, and then either bike

share, or a bus ride, and he sighs “it’s a really terrible commute, I only do it because I have two kids and its a nice town, and my in-laws can help babysit.” For him it is “obvious” that eliminating the commute is the best part of occasionally working from home, and the time saved will allow him to attend an upcoming school orientation for one of his kids. Patrick in looking for a coworking space, “didn’t want to spend too much time traveling.” Louis now lives within walking distance of his office, but when he had to take a 30-minute train ride he described his commute as “wasting an hour of my day going back and forth.” An interviewee who drives to work shared that notion of the commute as a waste of time then lamented that he had to “waste two hours on commute time” on days when he didn’t work from home, which he does one or two days per week.

For the nine full-time home-based remote workers, who did not engage in commutes for their current jobs, many perceived not having to commute as a primary benefit of their current work arrangement. Mary, a remote service manager in her 50s, previously worked in a downtown office, but began doing some teleworking after the office relocated and a “12-minute commute turned into an hour and ten minutes.” They eventually asked her to give up her desk and she worked as a remote-only employee of that firm for 5 years. After being laid off due to downsizing she followed a colleague to her current company where she was hired on as a remote-only worker. For Lisa, not commuting is the best part of working remotely. She states, “I miss the camaraderie. I don't miss the traffic.” Some other full-time remote interviewees felt the same way about “traffic.” Simon, a full-time remote worker, appreciates “the ability to manage your own time directly without having to deal with traffic.” Another remote worker, also a woman in her 50s, appreciated that she didn’t need to “keep up with the traffic.” For both

teleworkers with local offices, and those who telework from home full time, commuting experiences present and past can form a large part of their perception of the benefits of teleworking.

Understanding of Allowance of Remote Work: Flexible and Informal, yet Depends on Manager

Feelings towards one's commute and the use of cloud computing team collaboration platforms provide part of the context in which workers make decisions about work location on a given day. A third essential context element is the understanding of what is permitted by an employer, manager, and/or clients in terms of remote working. Best practices in the 1990s encouraged organizations to have formal policies and signed telecommuting agreements, such as the samples proved by a telecommuting handbook produced in 1991 with support from the Federal and California Departments of Transportation and the Federal Highway Administration (Shirazi et al. 1991). However, most of the interviewees in this study who discussed telework policies, describe them as "informal" or "unofficial"—enabled by either the tacit approval of a manager, or the tacit approval of both a manager and the organization broadly. For Antonio, who works at a finance firm, the allowance of telework from home occasionally is both "unofficial" and "informal" because an official policy states that all employees should be present in the office or else use a vacation or personal day. However his manager grants some leeway—perhaps because she "is also a parent and she works at home on days when there are school events and things like that." Kelly similarly says the allowance to work from home sometimes comes from her manager who is "okay with it"

and “really lax about sick days” for which he encourages working from home if you may be contagious.

In other organizations where doing some work remotely is not all that unusual, the policy is unofficial because of the tacit approval of the organization in addition to a manager, although in these cases most interviewees were not aware of any official organization policy. Patricia, the event planner at an organization with distributed offices says “it’s very flexible, if we ever need to work from home we usually do.” Judy works as a news assistant for an industry-specific blog, and works from home occasionally, but also observes her coworkers, especially the reporters, working remotely more frequently than she does. She describes the policy as “so informal you don't really ask, you just inform someone” as she recounts the awkwardness of asking permission. John says that while “the company is pretty supportive of it,” managers must oversee it, but that after a trial period, under most managers, “once you get that trust you can do it whenever.” Both of the interviewees that reported working under a more formal policy, described a six-month trial period before telework was made available. Some interviewees related their telework allowance to their success in their job, suggesting that their managers were satisfied with a results-oriented approach to evaluation. Antonio described this thusly: “I'm responsible for a certain number of things, as long as they get done no one’s too concerned if I'm there or not.” Mary, whose job consists of managing remote clients, states that “as long as no one is going up the chain of command, pretty much I do what I want.” Having some allowance to work remotely, as well as an awareness of that allowance is essential to its practice. As per the sampling frame for this study, all participants had at least some allowance to work remotely.

Perceptions of Productivity and Distraction: Differing preferences

Productivity and distraction were commonly spoken of in the same or adjacent breathes by interviewees. Some describe home as a place rife with distractions, which include roommates or partners, food, and entertainment. Rose, who is in her early 20s feels like she is "not getting penalized if I'm not on my phone or browsing other Internet sites and stuff like that." This raises concerns in her about productivity, such that "I feel like I don't get as much done as I could be getting done if I was in a work environment." Roy admits it's "hard to get focused at home" and strategically chooses days when his roommates are out to conduct work from home, which was also a practice for two other interviewees who lived with roommates. Kelly finds working at home more distracting and will "tend to go to the kitchen a bit more," and also considers working from home "more relaxing" and a good place to read documents.

However other interviewees, particularly full-time remote workers, saw themselves as more productive at home and/or considered the office to be a place of distraction. Agnes, an editorial consultant for nonprofit organizations, does most of her work at home but also spends time on site with her clients. She finds that in an office "too much time is spent socializing," which she considers to be "not productive." Mary, also a full-time home-worker shares the view that working from home is more productive, but misses the "chit chatting at the water cooler" and laments that "the personal touch has been removed." Simon, believes that "the watercooler chat so to speak, while beneficial for your mental health also wastes a lot of time" and that an eight hour day in a office consists of "probably working a dedicated 5 or 6 hours," partly due to time spent "answering mundane questions from people stopping by." More than anything else, the

perception of home over office or office over home, as being more productive and less distracting seems to be a matter of personal taste among interviewees, with some, including two full time home-based workers who identified themselves as only-children in discussing a preference for a quiet atmosphere, having strong opinions about home as the best option for them.

Day-of Decision Factors

The preceding four contextual factors—the use of team collaboration technologies, attitude towards commute and time spent commuting, understanding of the allowance of remote work, and perceptions of productivity and distraction—form the background against which interviewees make day-to day decisions about work location (Figure 7). Yet interviewees discussed numerous reasons pertinent to the day itself which motivate their decisions against this background. *Errands and chores*, including deliveries, were most commonly discussed by interviewees as a reason to take a day working from home. Rose, the music industry event planner, poses the dilemma as "if you work eight hours a day [in the office], it's kind of hard to schedule appointments". Louis, a computer programmer, describes the scenario as "if I order a couch online and I need to be here," as a reason to do some or all work from home on a day. Judy says that at her online industry news publication "everyone works from home at least once a week, and usually it's the day you do household chores". Other interviewees mentioned dry cleaning, house repair, cleaning, and cooking.

Interviewees described *parenting* as both a reason to—and to not—conduct work from home. Patrick, a self-employed video editor regularly makes the decision to work from a coworking space near his house in large part because, he says, "my kids are one

year old and four years and yeah, it's just not conducive to being productive [laughs], at all." However his flexibility and close proximity to home enable him to "participate in pick ups and drop offs a lot." Antonio only works from home when he needs too because of two small children, and while the reason is usually related to home maintenance, he expects to use the flexibility to attend school-related events in the future. Simon works from home full-time but often finds himself working on the go as he runs errands and shuttles around the kids, in part because his wife thinks working from home means he "can do whatever tasks she wants sometimes". Evelyn who got retrained as a court transcriber so that she would not have to rely on expensive daycare for her children, appreciates that as a full time homeworker "if one of them gets sick, I'm already home."

For some interviewees, *weather* contributes to a decision to work from home. Roy manages the office for a small e-commerce company that sells products through Amazon. Snow is the one time when he says he will "definitely stay at home." Patricia, the event planner says that "if its inclement weather [...] I'd really rather not walk all the way to the train". John loves his three-mile bike commute, but "if it's raining I don't really want to bike in to work […] I'll work from home instead."

Interviewees also discussed *illness* as a reason for working from home. John, the insurance company employee, has a rule that "if I'm not feeling too good I usually stay home." Judy, the news assistant, recounts times when she worked at home because she "just wasn't feeling well." One of the only scenarios in which Roy allows the employees he manages to work from home is if they are sick. Julia formerly worked as a teaching assistant locally and also did remote English teaching to students located in China and Brazil in the afternoons, evening, and weekends to make extra money. At one point she

was ordered by a doctor to stay home for over a week because she was contagious. While she could not participate in her local job that week, she could still teach online, and "worked 40 hours from home and stayed very social."

Some interviewees discussed strategically avoiding *congestion* during peak periods. On days when Douglas needs to visit a client, the consultant will "coordinate to work from home until the rush hour is done and then drive to the client." Rose, who works with mostly people in their 20s like herself, will work from home when she "can foresee it being packed" and will even query coworkers about the ride and "just ask like 'hey I'm just going to finish up, the subways are really busy right now, so I'll come in in a few hours.'" A few interviewees discussed using remote working in relation to a *vacation*. Rose's employer gives her the flexibility so that "I can travel on Thursday night after work and then I can wake up in wherever I want to go or wherever else and just do work from there." Judy did something similar when she worked remotely as a way of traveling to see family for an awkwardly placed mid-week July 4th holiday.

Finally, a desire for *socializing*, including both formal face-to-face meetings and more informal social gatherings is a day-of factor for some interviewees. Louis sometimes prefers to be in the office on a Friday because he says "a Friday at work should be very fun, maybe you guys go drinking, play some games," and working from home would mean missing out on those opportunities. However a couple interviewees who live outside the city also reported staying home to work when he has evening plans. James, whose day at home is fixed by firm policy, doesn't have flexibility to choose his location, and laments that "if we've got people that are from another office coming into the headquarters and I'm working from home that day then I don't get a chance to see

them in person." Full-time remote workers lacking a regional office to attend identified the lack of socialization as a major challenge. "Don't do it if your single […] it has killed my social life," warns Mary, who tries to compensate by using video conferencing as much as possible with her clients and coworkers.

Local travel on days when they worked from home was different than commute travel for some interviewees, either by mode, distance, or both, yet few interviewees avoided travel altogether and stayed home the entire day. Patricia, the event planner, will "usually take a walk to get a coffee, get a bagel" but will "tend not to take public transportation or drive anywhere" on days when she works from home. James says that when he works from home one fixed day per week, "I'll use a bicycle or I'll walk into town" instead of his usual train commute. Michael, a curriculum designer for an education startup is often "driving around" in the middle of the day to run errands and to get lunch on the four days he works from home each week.

Home was by far the most commonly discussed place from which to conduct remote work. However there were four interviewees who discussed working from coworking spaces. Patrick, who runs his own business with a partner, worked out a deal with a coworking space in his neighborhood that charges them a per-day rate (which is important because he sometimes works on-site with clients), but also allows him to maintain a desk. He finds most coworking space users are starting up businesses. The founders of one of the companies Dana works for on a freelance basis work from a coworking space, and "when we need to meet they invite us there, but for the most part its all remote." Kiana works from home some days, but also uses an app that allows her to work from various coworking spaces where she finds benefit in being "able to

network, but I'll also know I'll be able to focus and get work done." Several respondents also discussed working from cafes due to a *desire for a change of scene*. Tanya does remote data entry for an education startup through a website that also keeps track of her hours and productivity. She says she only goes to cafes if "I'm like really bored out of my mind and just want to belong in a social setting." Dana, as a freelancer, will try to break [the day] up by going to my local coffee shop or something just to be near other people." Christopher, who works in financial management finds "cafes where they are not playing music loud" to be "great places to think and write and read something that is difficult to understand."

While a limited set of qualitative interviews cannot create an exhaustive list of all the reasons why workers imbued with the contextual flexibility may decide on a particular location on a given day, the above list—errands and chores, parenting, weather, illness, congestion, vacation, socializing, change of scene—captures the main concerns discussed by these thirty-one interviewees in the New York metropolitan area. Yet a key finding of this study is that these diverse reasons are embedded in a wider context consisting of the individual's use of team collaboration technologies, their attitude towards commute and time spent commuting, their understanding of the allowance of remote work, and their perception of productivity and distraction.

iv. Conclusions: Team Collaboration, Informality, and Personal Preference Under the Mobile Cloud Computing

The inductive conceptual model of telework decision-making offered by this study reinforces findings from previous quantitative studies of telework decision-making, yet also offers new insights based on its qualitative approach and interest in computing

infrastructure. The most significant finding among the workers in this study is that they strongly rely on mobile cloud computing platforms to collaborate remotely on projects with their coworkers. This finding supports Bernardino (2017) in showing team-based employees making satisfactory use of an allowance to work remotely. Yet this project-based team collaboration now appears to be better supported under mobile cloud computing infrastructure over 20 years later and gives evidence to the growing import of virtual teams (Townsend et al. 1998). This finding also matches the third era of telework defined by Messenger and Gschwind (2016), that of the "virtual office" in which workplace functions are not grounded in physical space, but are rather accessible through networks.

Another key finding is that formal telework policies in the workplace give way to informal flexibility under mobile cloud computing infrastructure. Early telework advocacy materials, such as a guide released by the California Department of Transportation (DOT) in 1991 encouraged setting up highly selective and structured programs, which required employees signing a telecommuting agreement (Shirazi et al. 1991). According to a Teleworker Selection Guide (1997) published by the Oregon Office of Energy, telework in 1997 was only suitable to "the right kind of worker" with "the right kind of job" and "the right home environment." Yet, these for the workers in this study considered the ability to telework at least some of the time in much less strict and formal terms, where they did not need to ask permission or keep colleagues informed of their location. However even in the face of this informal flexibility under mobile cloud computing, managerial attitude and approval still matter greatly to interviewees, in particular the need to establish trust in order to gain that informal flexibility. Nonetheless,

the images of the teleworker as needing to be tightly controlled, as a solitary figure, or as a rarified breed imbued with special discipline, should be put to rest once and for all under mobile cloud computing.

A third finding is that while these workers in the New York Metropolitan region certainly don't like commuting and consider it to be a waste of time, they do prefer being in the office for certain tasks, meetings, and events. This finding agrees with Mokhtarian and Salomon (1997) who showed that perceptions of commuting and distraction are important context factors in decisions regarding telework. It also supports Cooper and Kurland (2002) in finding concern among participants with missing out on the social aspects of the office. Under mobile cloud computing, workers use their informal work location flexibility to decide where to work based on how the needs of the tasks at hand meet with their personal preferences concerning distraction and productivity. Here under mobile cloud computing, we can lastly set to rest the idea of some tasks being universally more appropriate for teleworking, as workers in this study showed great personal preference in matching tasks with different locations.

Finally the model itself represents a finding with potential utility. It found four contextual factors set the stage for day-of decision-making: computing infrastructure, attitude towards commute and time spent commuting, understanding of the allowance of remote work, and perceptions of productivity and distraction. These contextual factors inform the specific factors that drive the immediate decision, which include errands & chores, parenting, weather, illness, congestion, vacation, and a desire for change of scene. While this model, based on a non-probability sample, is not generalizable to the wider population, its focus on younger knowledge workers in urban areas might be a sign of

things to come. One potential application for this model is to frame and direct the incentivizing of telework. Incentives could be applied in either real time (day-of) or broadly (context) in order to flatten peaks or reduce overall travel. This idea will be revisited and expanded on in the concluding chapter of this dissertation.

Chapter 7: Remote Work in the New York Metropolitan Area Survey Results: Mobile Cloud Computing and the Loosening of Spatial Constraints Towards Personal Autonomy

The practice of telework is both enabled and continually shaped by socially embedded forms and instantiations of information and communication technologies (ICTs). Even as researchers acknowledge that many of the key barriers to telework are non-technical in nature, we must also consider how changes to embedded technological infrastructure interact with these challenges in specific teleworking contexts. In this chapter I seek to do just this, by using data collected from a survey of 185 remote workers in the New York City Metropolitan Area to test the effects of an individual's use of mobile cloud software platforms—such as those allowing messaging, document sharing, and video conferencing across devices and locations—on their reasons to telework from home. I find that the more engaged workers are with mobile cloud software platforms, the more importance they give to reasons for working from home that represent greater personal autonomy, such as reducing stress or easing commuting, compared to more compulsory reasons for teleworking such as having excess work or parenting. These findings support past research on how ICTs can loosen spatial constraints related to work, while highlighting the particular role of mobile cloud software platforms in doing so and the nature of its effects. Other findings show that women are more likely to work from home in order to reduce stress and to find focus outside of the office, and those workers with children do use flexible work locations to support parenting. Finally, survey results show that trips made while working a full day from home are more likely to use active modes of transportation on that day, and that

over half of office workers in the sample reported using teleworking to avoid morning peak travel. In my conclusion I consider the implications of loosening constraints towards greater personal autonomy for both worker well-being and transportation demand management.

i. Background: Telework, Computing, and Space-Time Constraints

Telework practice is considered in relation to the last of three phases of computing infrastructure: centralized, personal, and mobile cloud. The concept of telecommuting first appeared in the Los Angeles metropolitan region as a means of confronting the automobile-related problems of traffic congestion and air quality. Its initial design was rooted in a centralized mode of computing that describes an arrangement in which computer processing is centrally located and managed in an organization (King 1983). The hypothetical program imagined computer input terminals installed in a suburban center near to worker's homes, connecting to a mainframe computer system located in a central business district office (Nilles et al. 1976). Teleworking from one's own home was not a part of this first imagining of telework. However a 1977 model soon considered a terminal installed in the worker's home instead of in a neighborhood center (Lopez and Gray 1977). The adoption of personal computers starting in the late 1970s—through which workers more directly controlled their own processing power as users of individual computing machines—raised questions about the configuration and ownership of the equipment used in teleworking arrangements. The 1980s was a period of transition between centralized computing infrastructure and personal computing. An evaluation of a telecommuting pilot program by the government of California found that by 1989, 83 percent of teleworkers owned personal home

computers, and preferred that option over having a state-owned computer placed in their home (Nilles 1990).

Mobile cloud computing infrastructure emerged alongside the Internet and was bolstered by the adoption of portable computers and Internet-enabled mobile phones. Through mobile cloud computing—which relies on remotely-located and distributed servers for computer processing, data, and file storage, accessed through the Internet or private network—content and functionality is shared among stationary and portable computing devices. Software, which was previously wholly executed on a local device, is now delivered "as a service" through a network connection (Mell and Grance 2011). A user accessing their work email through both a work computer at the office, their personal computer at home, and their personal smartphone from the train, is an example of a common application of mobile cloud computing. However individuals and organizations have adopted diverse cloud platforms for uses beyond email communications such as the online customer relationship management (CRM) platform Salesforce.com, which makes a database of information on contacts available across teams and devices.

Two concepts in recent literatures are helpful for understanding the interactions of mobile cloud computing with telework and travel: space-time constraints, and activity fragmentation. The notion of space-time constraints derives from a framework of three varieties of limitations on individual action in space/time: "capability constraints", "coupling constraints", and "authority constraints" (Hagerstrand 1970). Capability constraints relate to the activities that one can accomplish based on their biological abilities augmented by any tools that are available to them within a given space; coupling

constraints refer to the need to co-locate with people or things in a given space to accomplish an activity; authority constraints refer to power of those in control of a space to control the activities that occur within them (Hagerstrand 1970). Kwan (2002) considers the ways that ICTs result in “constraint relaxation” by potentially loosening constraints and thus changing the location, timing and nature of people’s actions. An empirical study based in this understanding found that while ICT use did relax constraints across these categories, temporal fixity was more strongly loosened than spatial fixity, and the particular social contexts mattered greatly to these effects (Schwanen and Kwan 2008). Workers are not without agency in the loosening of space-time constraints on work location. Erickson and Jaharri (2016) have shown how capability and authority constraints comprise “infrastructure seams" that mobile knowledge workers overcome in order to conduct work remotely from some spaces.

Mokhtarian (1990) first raised the notion of “hybrid situations”, such as the example of home video viewing, which is akin to a telecommunications innovation in the how it allows the viewing of movies from home, yet still comprises trips to retrieve and return the video. Yet it was under the growing dominance of mobile cloud computing infrastructure, that Helen Couclelis (2004) coined the term activity fragmentation, stating, “it is not the distance that is dead, it is the activity that is disintegrating.” She argued that ICTs have an effect on individual’s perceptions of action and that activities now spread across space and time in new ways. She subsequently offered a multidimensional framework that maps the physical-virtual barrier representing time geography in an age of networked ICT (Couclelis 2009). Alexander et al. (2010) defines activity fragmentation as “the decomposition of work into multiple segments of subtasks that can

be performed in different times and/or locations," and empirically observes varied configurations of fragmentation dependent on how individuals engage with ICT, such as laptops being associated with fragmentation across space, and handheld mobile Internet devices being associated with fragmentation across time. Schwanen at al. (2008) sees activity fragmentation as created through the decoupling of activities from space and time—essentially the undoing of coupling constraints—as well as the related circumventing of authority constraints. In a recent study, Hubers et al. (2018), found an effect of the adoption of ICTs on the fragmentation of work activities, but found differences based on gender, including that women were more likely to use telework to spatially fragment work activities.

Researchers have examined the factors that shape the decision-making of both employees and employers in relation to telework. Examining the outcomes of telework programs at Fortune 100 companies, Olson (1989) determined that managers preferred to have workers located in the office rather than teleworking, and that there were no significant productivity differences between home workers and those working in the office among the programs. Workers, alongside their managers, also worried about a negative effect from teleworking from home on their career development (Duxbury et al. 1987). One early conceptual model of telework decision-making was composed of factors that constrain telework, factors that facilitate telework factors, and factors that drive telework (Mokhtarian and Salomon 1994). Among the factors hypothesized to facilitate or constrain telework for an individual are type of job, being aware of the allowance of telecommuting, organization support or access to the technology to do so. Driving factors point to various motivations, such as being more productive, avoiding commuting, having

more time for leisure, desiring independence, or choosing to be more environmentally conscious (Mokhtarian and Salomon 1994). A subsequent operationalization of this model using surveys found that distractions at home and missing out on workplace socialization were among the significant constraints, while perceived stress, commute time, and desiring independence were among the significant drivers (Mokhtarian and Salomon 1997). Professional isolation was also found to be problematic for home-based teleworkers in part because professional development activities are often spontaneous or informal, such as the learning that takes place in a cubicle (Cooper and Kurland 2002).

The notion of personal autonomy has been of recent interest to telework researchers. Kossek at al. (2009) found in a survey that not all types of work flexibility were correlated with greater well-being and less work-home conflict, and that the most beneficial form was personal autonomy wherein the worker makes decisions about their own work time, location and methods. However Sewell and Taskin (2015) show through interviews with participants in a telework program and their managers, how the apparent personal autonomy of telework arrangements can represent negotiated outcomes of new arrangements of social control, such as email and phone communication being used to verify presence of teleworkers.

Finally, the literature on virtual teams is relevant to this study through its exploration of the role of more recent technologies with teleworking. Under mobile cloud computing, the emergence of virtual teams as a practice is related to shifts in organizational structures and worker preference to favor flexibility, as well as the need for individuals collaborating on projects to have less frequent face-to-face interactions, and instead coordinate remotely (Townsend et al., 1998). Indeed the interaction between

physical and virtual communications is of interest to virtual teams researchers. In a study of distributed teams of decision makers, Maznevski and Chudoba (2000) found that occasional physical meetings were essential to successful virtual interactions in how they set the agenda for what would be accomplished. Mobile cloud computing platforms have been the focus of some virtual teams research. Having mobile email access was found to give a perception of flexibility and control to virtual team members over their role in projects, but it also had an opposite effect in creating challenges to work-life balance (Mazmanian 2013). Loeschner (2017) highlights the importance of mobile cloud-based communication by considering collaboration among team members in the case where a mismatch in mobile email access exists across groups within the team. Finally, Jaharri and Sawyer (2012) see a vast array of social technologies, including email, online forums, wikis, blogs, messaging, and social networks both competing and collaborating to give access to expert knowledge and to the experts themselves, while also working together to provide a means of socializing among virtual teams. However a research gap exists in that mobile cloud platforms designed specifically for team and project communication have not yet been incorporated in research on virtual teams (Martins et al (2013).

This chapter will contribute to the existing body of literature by using empirical data to consider the ways in which uses of mobile cloud computing platforms interact with decision-making about work location and telework. In short it intends to test one of the premises of Kossek et al. (2009), namely that information and communication technology—in this case mobile cloud computing platforms—do contribute to increased personal autonomy. In doing so, it will shed further light on how information and

communication technologies embed in specific social contexts to potentially loosen constraints on work location, and enable work activity fragmentation. This study's findings, which feature the use of mobile cloud team collaboration platforms, can also similarly contribute to the virtual teams literature. Finally, this study can contribute to transportation systems practice by shedding light on practices that have implications for travel patterns and travel demand.

ii. Data And Methodology

This paper is based on an analysis of quantitative data collected through an online survey of a purposive sample of 185 remote workers in the New York City Metropolitan Area. The survey was administered online from mid-2017 through mid-2018. A purposive sample, unlike a random sample, does not seek to be representative of a region or group, but rather to include members of a population with a particular experience that is of interest to the study, in this case conducting work remotely aided by information and communication technology. Recruitment targeting this population was done through free and paid posting on social media platforms including Facebook, Reddit, and LinkedIn and Craigslist, the author's professional and personal networks, and the distribution of flyers in coworking spaces and cafes. The survey instrument covered various topics, including the locations from which the respondent conducts work, reasons for choosing to conduct work remotely from select locations (home, cafes or coworking spaces), attitudes towards technologies used for remote working, modes of travel, and basic demographic information. It consisted of 47 close-ended questions, however through skip logic, not all questions were asked of all respondents. For example questions about café-based work were only asked of respondents who indicated they conducted work from a

café. Key characteristics of this sample (Table 6) show that it contains slightly more men than women and that over three quarters of the sample has a college degree or higher. It is notable, and should be borne in mind, that nearly half of the sample is in between the ages of 25 and 34 and that workers over the age of 44 are not well represented by this study. Recruitment sought to include both full-time home-based workers and those that did work from home only occasionally or for partial days. As such, half of the sample consists of those whose main work location is the office of their employer, while the other half works primarily from home, a coworking space, or another location or locations.

TABLE 6: Key Characteristics of Purposive Sample of Remote Workers in NYC Metro Area (n=185)

Variable	*Values*	*Pct*	*Cnt*	*Variable*	*Values*	*Pct*	*Cnt*
Gender	Female	44%	82	*Education Level*	Less than college	24%	45
	Male	56%	103		College degree	43%	80
Age	18 to 24	16%	29		Graduate degree	33%	60
	25 to 34	48%	89	*Primary Occupation*	Business	37%	68
	35 to 44	20%	37		Technical/design	34%	63
	45 and older	16%	30		Education/training	14%	25
Race	White	66%	123		Other	15%	28
	Black or Latino	15%	28	*Personal Income*	Less than $40K	27%	50
	Asian	14%	25		40K to 80K	37%	69
	Other	2%	4		More than 80K	36%	66
	No answer	3%	5	*Main Work Location*	Office of Employer	49%	90
Has Children <18	Yes	20%	37		Own Home	31%	58
	No	79%	146		Coworking / Other	20%	37
	No answer	1%	2	*Work Status in Primary Occupation*	Employee of org.	78%	143
Urbanity of Residence	Urban high rise	26%	48		Freelancer	19%	35
	Urban low rise	46%	84		Owner or start up	9%	16
	Suburban	23%	42		Other	3%	6
	Small town / rural	5%	10	*Work Status in Secondary Occupation*	N.A.	80%	148
Living Arrangement	With partner	44%	81		Employee of org.	3%	6
	With fam. / rmates.	30%	56		Freelancer	10%	18
	Living alone	24%	45		Owner or start up	6%	12
	Other	1%	2		Other	1%	1

This chapter's methodology consists firstly of a descriptive analysis of the prominence in the sample of the various non-office locations from which respondents reported conducting work, respondent perceptions of the challenges to remote work, as well as the importance they attribute to technology platforms in their practice of remote

work. Secondly, it uses multivariate analysis to model reasons for the decision to engage in home-based work. Dependent variables for these models consist of scales of the importance given by the respondent to each reason for conducting work from home—such as "reducing stress" or "weather." The independent variable of interest in all models is a mobile cloud index variable that measures the respondent's broad engagement with mobile cloud software platforms in their remote work practice. This index variable was developed by compounding scales of the importance respondents gave to cloud-based software platforms such as "messaging" and "document sharing." I hypothesize that greater engagement with mobile cloud software platforms will loosen constraints in ways that result in greater personal autonomy for workers. Additional independent variables included in these models consist of primary work location and various demographic and geographic variables, including gender and urbanity. Lastly, this chapter's analysis conducts a descriptive analysis of travel modes based on work location, and peak avoidance behavior to gain some understanding of the implications of constraint loosening for travel.

iii. Results

Locations, Attitudes and Use of Technology

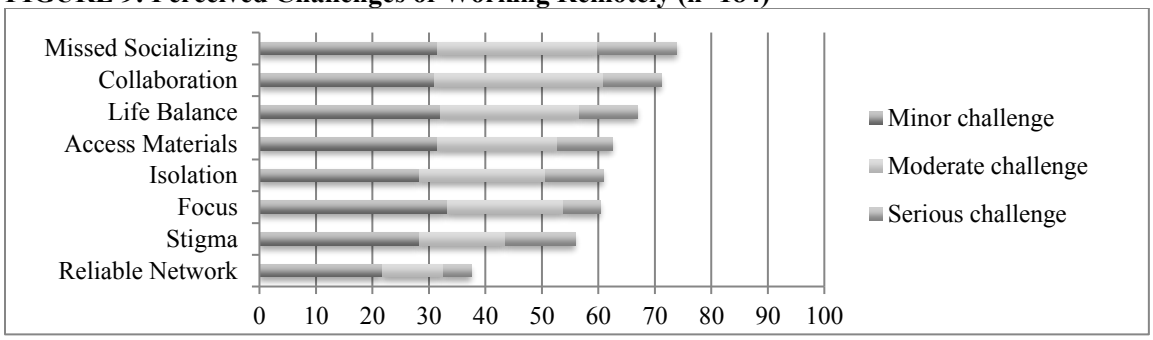
Home was by far the most common non-office work location from which respondents reported conducting work. Working from home for full days—either full time or occasionally—was reported by 38% of respondents, while 46% of respondents reported working home for partial days. In total 82% of the sample reported conducting at least some work from their own homes. However 72% of respondents reported conducting work from two or more types of non-office locations, which includes non-

home and non-office locations such as cafes, airports, vehicles, client's offices and coworking spaces (Figure 8). Cafes were the second most common non-office location from which to conduct work, with half of respondents indicating that they do so at least occasionally. One third of respondents indicated that they conduct work from airports or from vehicles. Over one quarter of respondents reported that they conducted work from client's offices, coworking spaces, or other people's home's. Finally, 13% of respondents indicated they conducted some work from the office of another job.

FIGURE 8: Non-Office Work Locations Worked From at Least Occasionally (n=185)

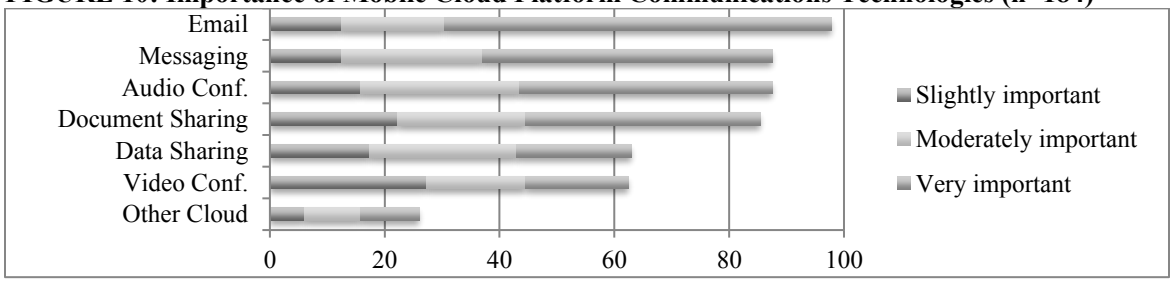
The three most strongly perceived challenges to working remotely, shown in figure 9, are missing out on the socializing that takes place in an office workspace (42% moderate or serious challenge), added difficultly of collaborating with coworkers (40% moderate or serious challenge), and maintaining a balance between work and home life (35% moderate or serious challenge). Less than one third of respondents considered accessing materials, isolation, focus, and stigma to be a moderate or serious challenge. Finally, and notably, reliable network access was least among the reported challenges to conducting work remotely, with only 16% of respondents describing it as a moderate or serious challenge.

FIGURE 9: Perceived Challenges of Working Remotely (n=184)



In terms of the software platforms that remote workers consider important to their practice of remote work, email was reported used by nearly 100% of respondents, with over 85% indicating that it was moderately or very important to their remote working. However three other types of software platforms were reported as used by over 80% of respondents for remote working: messaging platforms such as Slack (75% moderately or very important), audio conferencing platforms such as Skype (72% moderately or very important), and document sharing platforms such as Dropbox (63% moderately or very important). Additionally data sharing platforms such as Salesforce, were considered moderately or very important by 20% of respondents, while video conferencing was considered moderately or very important by 17% of respondents. Other cloud platforms that were written in by respondents included project management platforms such as Jira, version control platforms such as Github, and organizational resource planning platforms such as Workday.

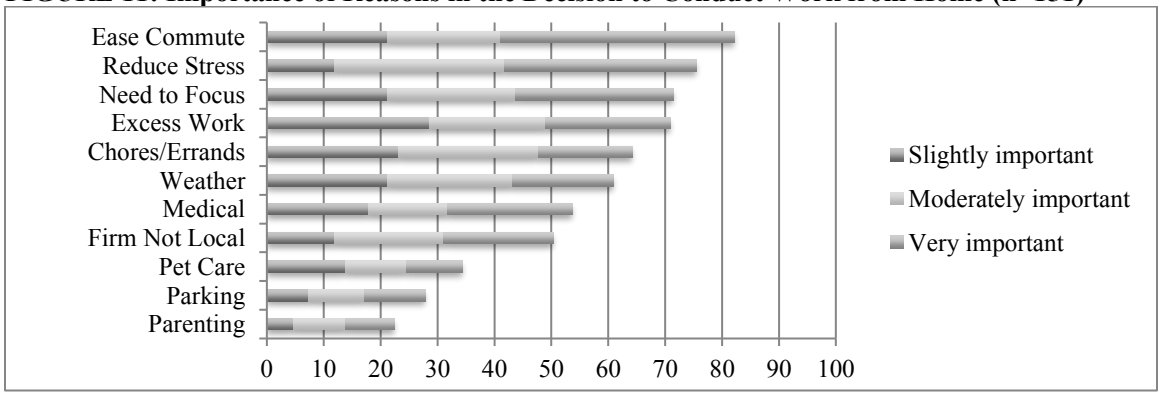
FIGURE 10: Importance of Mobile Cloud Platform Communications Technologies (n=184)



Mobile Cloud Platforms and the Decision to Work from Home

A principle interest of this chapter is the relationship between the use of mobile cloud technologies and the decision to conduct work remotely. With 82% of respondents reporting that they conduct work from their own homes, this relationship will be explored by modeling the determinants of the reasons for the decision to conduct work from home, with the use of mobile cloud platforms as the key independent variable of interest. Reasons for home-based work were pre-selected for the survey instrument and for each, respondents were asked to rate their importance on a four-point scale. The prominence of reasons as rated by respondents is shown in Figure 11. Over 80% of respondents considered easing their commute as an important part of their decision to conduct work from home, with 61% considering it to be moderately or very important. Other strongly cited reasons for deciding to work from home were reducing stress (64% moderately or very important), a need for focus (50% moderately or very important), and having excess work (42% moderately or very important). While parenting was only cited as moderately or very important by 18% of the sample, this reflects its great prominence among the only 20% of the sample that indicated that they were parents of children under 18.

FIGURE 11: Importance of Reasons in the Decision to Conduct Work from Home (n=151)



The independent variable of interest in this model is an index created from respondent's readings of the importance of various mobile cloud technologies to their remote work. Two versions of this index variable were created. The first included email, a technology that nearly all respondent indicated as at least somewhat important, while the second version excluded email. Both variables yielded similar results when placed in models, and the model using the former will be presented in this chapter. I hypothesize that respondents who give greater importance to mobile cloud technologies in their remote work will give greater importance to reasons for working from home that represent personal autonomy. These reasons are the ones that are less constrained such as easing commute, finding focus, and reducing stress, as opposed to those that are more tightly constrained such as parenting and having excess work. The causal mechanism of this hypothesis is that the use of mobile cloud technologies by virtual teams reduces the negative effects of they are being spatially distributed thereby making it easier for individual members to make telework decisions that suit their personal needs.

Standardized results from nine ordered logit models of the determinants of these reasons for home-based working show are shown in Table 7. Firstly, looking at the effect of the independent variable of interest across all models shows a clear relationship between the use of mobile cloud platforms and work location decision-making. A respondent's level of engagement with mobile cloud technologies shows a statistically significant positive effect at the 99% confidence level in models for four of the reasons for home-based work (ease commute, reduce stress, find focus, weather), and at the 95% confidence level in models for three other reasons (medical, parking). The strongest effect of mobile cloud technology use is on easing commuting as a reason for working

from home—a one unit change in the mobile cloud technology use index will result in a 0.168 change in the log-odds of being in a higher category of importance for that reason. The next strongest effects are for finding focus, reducing stress, and weather. These results indicate that workers that are more deeply engaged with mobile cloud platforms consider these factors to be more important to their decisions to work from home, even while controlling for differences, such as income, occupation, and urbanity.

Looking at individual models points to factors in addition or instead of ICT that are correlated with reasoning on work location. The models for reducing stress and need to focus, show a statistically significant positive effect at the 99% confidence level for being female in addition to mobile cloud platform usage, indicating that women are more likely to work from home in order to reduce stress or to find focus. In both of these models the standardized effect of being female are nearly as strong as the standardized effects of mobile cloud technology use. The model for excess work shows a significant positive effect at the 99% level for being non-white, suggesting these workers are taking more work home with them to complete during outside work hours. The parking model shows that having a higher personal income is strongly associated with less concern for the parking as a reason to work remotely. Finally, not surprisingly, having children is strongly associated with citing parenting as an important reason for working from home, with that standardized effect being the strongest observed in any model, suggesting that for parents, remote working is a very important option.

Remote Work and Travel

The effect of teleworking from home on travel mode depends on whether an individual works for the full day from home, or for a partial day while also attending their

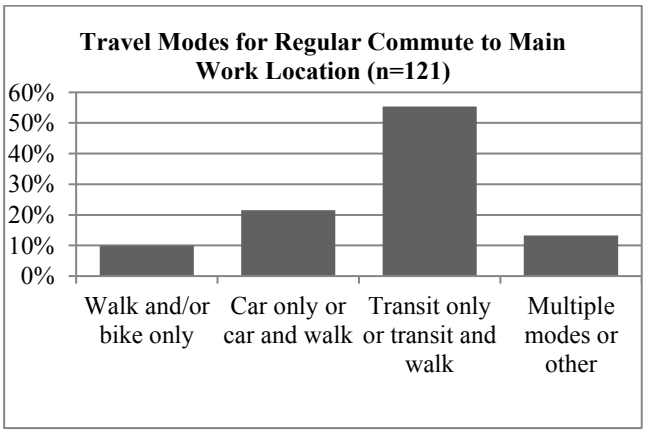
TABLE 7: Determinants of Reasons for Home Based Working Among NYC Area Remote Workers (n=129)

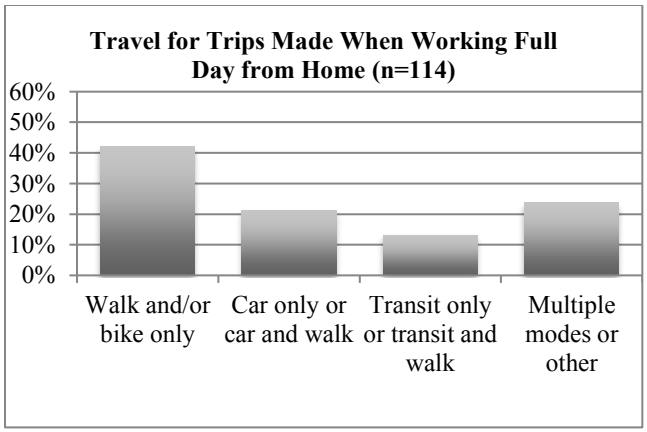
	Ease Commute		Reduce Stress		Find Focus		Excess Work		Weather		Medical		Firm not Local		Parking		Parenting	
	Beta	*Sig*	*Beta*	*Sig*	*Beta*	*Sig*	*Beta*	*Sig*	*Beta*	*Sig*	*Beta*	*Sig*	*Beta*	*Sig*	*Beta*	*Sig*	*Beta*	*Sig*
Mob. Cloud Index	0.168	***	0.132	***	0.145	***	0.064		0.130	***	0.094	**	0.086	*	0.117	**	0.084	
Personal Income	-0.146		-0.310	**	-0.072		-0.116		-0.399	***	-0.159		-0.033		-0.850	***	-0.089	
Has Adv. Degree	-0.437		0.205		0.050		0.579		-0.127		-0.697		-0.423		-0.042		0.247	
Non-White	0.154		0.237		0.160		1.151	***	-0.325		-0.188		-0.159		-0.117		-0.322	
Female	0.302		1.108	***	1.235	***	0.662	*	0.754	*	0.077		0.263		-0.771		-0.652	
Has Children	-1.140	**	-0.641		-0.717		-0.135		0.189		0.134		0.387		1.894	***	5.614	***
Has Housemates	-0.163		0.243		-0.117		-0.502		-1.153	**	-0.936	**	-0.199		-1.944	***	-0.322	
Age (Base:18 to24)																		
25 to 34	0.100		1.378	**	-0.451		0.207		2.206	***	1.132		1.120		1.889	*	1.373	
35 to 44	0.061		1.990	***	0.715		0.162		1.945	**	1.006		0.761		1.134		0.422	
45 and Older	0.314		1.005		-0.362		0.589		0.497		0.599		0.789		1.205		-1.655	
Freelance/Owner	-0.169		-0.412		-0.722		0.039		0.483		0.207		0.417		-0.040		1.289	
Second Occupation	0.016		0.093		-0.274		0.254		-0.219		0.693		-0.713		0.664		-0.478	
Occupation (Base:Business)																		
Technical/Design	0.658		0.824	*	0.321		-1.332	***	-0.284		-0.977	**	1.011	**	-0.452		-0.128	
Educ./Training	-0.102		0.921		0.357		-0.722		-0.493		-1.526	**	0.021		-0.220		0.022	
Other	-1.264	**	-0.849		-0.663		-0.882		-1.446	**	-0.306		0.187		-2.291	**	-0.420	
Satisfied with Occ.	-0.459	**	-0.162		-0.155		0.132		-0.327	*	0.267		-0.227		-0.593	***	-0.881	***
Primary Work Site (Base: Office)																		
Home	0.214		0.240		0.346		-1.734	***	-1.630	***	-1.152	**	2.115	***	1.011		-0.257	
Cowork / Other	-1.416	**	-1.082		-1.894	***	-1.041		-0.388		-0.902		1.177		0.917		1.357	
Live in Urban	-0.226		-0.041		-0.102		-0.204		-0.970	*	-0.168		-0.672		-1.865	**	-2.899	***
Work in Urban	0.132		-0.231		0.295		-0.021		0.016		-0.417		0.098		1.033		1.683	
Distance to Work	0.028		-0.003		0.016		-0.014		0.020		0.040	**	0.018		0.058	**	-0.020	
	R^2=.148		R^2=.139		R^2=.123		R^2=.157		R^2=.184		R^2=.141		R^2=.161		R^2=.253		R^2=.362	

*Models for "Chores/Errands" and "Pet Care" not significant; **p<0.05, ***p<0.001; R^2 represent Pseudo R^2*

office, as this difference determines whether they engage in their regular commute or not on a given day. I will firstly review the apparent mode shift that results from workers working full days at home. The survey instrument asked office-based workers about the modes used in their regular commutes. For respondents who indicated that they conducted work from home for a full day at least occasionally, the survey instrument asked what modes they use for trips taken on days when they work from home. A comparison of these results in Figure 12 shows a distinct difference between travel modes between regular commute travel and home-based work travel. For regular commutes in this transit rich metropolitan environment, 55% were transit-based, 21% were car-based, and those traveling by active modes only was 10%. For trips by workers on days working from home, those engaging in only active modes of transportation is increased to 42%, while those using transit is decreased to just 13%. The percent of car-based trips was 21% in both cases, which may point to a lack of perceived viable transportation alternatives in car dependent suburban area.

FIGURE 12: Travel Modes by Work Location





Partial-day teleworking among office workers does not eliminate regular commuting patterns, however it may change its timing, which has implications for peak travel periods. Respondents whose primary work location is the office of their employer and who indicated that they also conducted work from home were asked how often they telework in the morning to avoid rush hour, which 56% indicated they did at least occasionally. A cross tabulation of this variable with the existence and knowledge of a telecommuting policy (Table 8) shows that workers who work under a telecommuting policy are more likely to use telework strategically to avoid peak travel times. Among those working under a clear policy, 76% indicate they do avoid morning peak travel by working remotely at least occasionally, compared to 39% of those who do not have a clear telework policy.

TABLE 8: Cross Tabulation of Telecommuting Policy and Telework to Avoid Morning Rush Hour Among Office Workers (n=86)

	Telecommuting Policy					
	Has Clear Policy		No or Unclear Policy		*TOTAL*	
Telework to Avoid Morning Rush Hour	Cnt.	Pct.	Cnt.	Pct.	*Cnt.*	*Pct.*
Never	9	24%	29	60%	*38*	*44%*
Occasionally	19	50%	14	29%	*33*	*38%*
Moderate Amount or Often	10	26%	5	10%	*15*	*9%*
TOTAL	*38*	*100%*	*48*	*100%*	*86*	*100%*

Note: The Cramer's V value is 0.373; p=0.003

iv. Conclusions: Loosening Constraints Towards Personal Autonomy

Results from the multivariate analysis show a clear positive relationship between worker engagement with mobile cloud software platforms and the importance they give to specific reasons for teleworking at home, while controlling for demographic and employment characteristics. The four reasons showing the strongest effects from the use of mobile cloud computing platforms were easing commute, reducing stress, finding focus, and weather. What these four reasons have in common is that they represent workers claiming personal autonomy for distinctly personal benefits. Teleworking from home in order to ease commuting represents a choice to save time or avoid an unpleasant peak period a choice to increase psychological health and wellbeing. Teleworking from home in order to find focus represents a choice towards making the best use of your own time in accomplishing work activities. Finally, teleworking from home in order to avoid weather represents a choice to avoiding unpleasant or potentially dangerous conditions. I argue that this choice is in-part made possible by the use of mobile cloud technologies by virtual teams.

These four reasons contrast with reasons that were not found to have a significant relationship with the use of mobile cloud computing platforms, such as having excess work and parenting, which would tend to be, though not always, more reactive and compulsory. Indeed excess work as a reason to conduct some work from home predates the practice of telework. The concept of a "home office" as a designed space emerged in the 1950s and 1960s, and was imagined in part to serve office workers who needed to do excess work on evenings and weekends ("Home Office Should Be A Quiet Place" 1969). Results from this study show that the use of mobile cloud computing platforms does not

influence excess work as a reason for teleworking from home for the 40% of respondents that indicated that excess work was moderately or very important in their decisions to conduct work from home.

The loosening of constraints under mobile cloud computing infrastructure in ways that promote greater personal autonomy, has implications in the policy sphere for both worker well-being and travel demand management. In terms of well-being, Kossek at al. (2009) found that personal autonomy was the most supportive type of spatial and temporal flexibility for both worker well-being and reduced work-life conflict. Yet the findings of Sewell and Taskin (2015), who show how the apparent personal autonomy of telework arrangements represents negotiated outcomes of new arrangements of social control, should be borne in mind as they suggest an underlying complexity to the social relations of teleworking. Further research should seek to connect these quantitative and qualitative understandings of the outcomes of personal autonomy within telework. In regard to travel demand management, mobile cloud computing creates new and opens old opportunities for planners to shape travel in a region, as will be discussed in the concluding chapter.

Chapter 8: Conclusion: Planning With Telework Under Mobile Cloud Computing

This dissertation began by outlining its two related research questions, one historical and one empirical. The historical question asked: *how has planning, in relation to technological change, mediated individual work location practices in the United States?* The empirical question asked: *how does the adoption of mobile cloud computing platforms impact work location decision making and travel outcomes among workers in a multimodal metropolitan regional context?* In this brief concluding chapter I will first summarize the findings under each of these research questions, and describe limitations of these findings. Secondly I consider a practical application for these findings through informing programs that use app or smartcard-based incentives to manage travel demand. Finally I review the theoretical implications of these findings in considering the ways in which how we compute as a society has implications for how we plan as a society.

i. Review of Findings

How has planning, in relation to technological change, mediated individual work location practices in the United States?

Finding 1: Work location has been an interest of planning practice in the United States since its inception, by way of zoning, land use transport modeling, and telework

As discussed in Chapter 3, through the 1980s and 1990s, the notion of "telecommuting" became one strategy for transportation demand management. Yet as found in Chapter 2, the interest in planning in the location of individual work predates the era of telework. In particular, early planning practice promoted a separation of home and work, through

zoning and related ordinances, in part as reaction to perceptions of home-based work in tenement districts. Furthermore, this distinction later became embedded in the early methods of land use and transportation planning as planners embraced this separation of home from the workplace, which their discipline had previously helped to establish. Seen in this light, telework was a continuation of an existing interest of planners in work location, rather than a newfound interest.

Finding 2: The history of telecommuting advocacy in the US represents a case of strategic niche management, which supported a limited reconfiguration of work location practices

In its first three decades, beginning in the 1970s, telecommuting advocacy showed the fundamental elements of strategic niche management as defined by Schot and Geels (2008): a vision and expectations, learning processes, and social networks among advocates, while providing protected spaces for the practice of telework. The historical analysis in Chapter 3 shows how, in doing so, it provides an early case of strategic niche management from which future practice can learn. Yet while these efforts of advocates contributed to a reconfiguration of work location practices in the workplace, due to a weakening of telecommuting's original environmental vision, its sustainability benefits are now unclear, and the ultimate outcome depends on factors beyond the control of its advocates.

Finding 3: Computing infrastructure influenced the representation and practice of telework

The earliest practices of telework developed under a centralized computing infrastructure with mainframe computer systems accessed by authorized employees through remote

input terminals. Personal computing reframed the home as a space of self-entrepreneurship, while portable personal computing highlighted the technical challenges of uneven access to networks and work materials across computing contexts. Finally mobile cloud computing supports solutions to the technical problems highlighted by portable personal computing, yet contributes to perceptions of challenges of work life balance.

How does the adoption of mobile cloud computing platforms affect work location decision-making and travel outcomes among workers in a multimodal metropolitan regional context?

Finding 4: Teleworking from home is growing in the United States since 2003 and is associated with reduced overall travel time and reduced likelihood of participation in peak hour travel

The analysis of American Time Use Survey data provided in Chapter 5 showed that teleworking is growing in the United States, and found a significant relationship between both full-day and part-day telework with peak hour travel demand, showing workers more likely to avoid participation in morning peaks than evening peaks. Additionally the analysis found that full-day telecommuting is associated with less total daily travel time.

Finding 5: Computing infrastructure is part of the context of telework decision-making; Under mobile cloud computing, workers use platforms for team collaboration, formal policies give way to informal flexibility, and workers choose location based on tasks at hand

An analysis of interviews with 31 workers in the New York Metropolitan area yielded a conceptual model of telework decision-making. Four contextual factors set the stage for

day-of decision-making: computing infrastructure, attitude towards commute and time spent commuting, understanding of the allowance of remote work, and perceptions of productivity and distraction. These contextual factors inform the specific factors that drive the immediate decision, which include errands & chores, parenting, weather, illness, congestion, vacation, and a desire for change of scene. Interviews showed that mobile cloud computing platforms were used for collaboration with team members on projects.

Finding 6: The use of mobile cloud computing platforms is associated with reasons for telework that represent greater personal autonomy

The analysis of a survey of 185 workers in the New York Metropolitan area who do at least some work remotely found that the more engaged workers are with mobile cloud software platforms, the more importance they give to reasons for working from home that represent greater personal autonomy, such as reducing stress, finding focus in work tasks, easing commuting, or weather. These findings support past research (Schwanen and Kwan 2008) on how ICTs can loosen spatial constraints related to work, while highlighting the particular role of mobile cloud software platforms in doing so, in ways that represent the exercise of personal autonomy for psychological health and wellbeing.

ii. Limitations

Research design and data collection represent a series of tradeoffs, in which each decision strengthens the validity of a study in some respects, while often weakening it in other respects. As such, the research contained in this dissertation has limitations that are established by design choices, as well as the availability of data. In the empirical portion this dissertation, comprising chapters 5, 6 and 7 each of the three data sources has its own

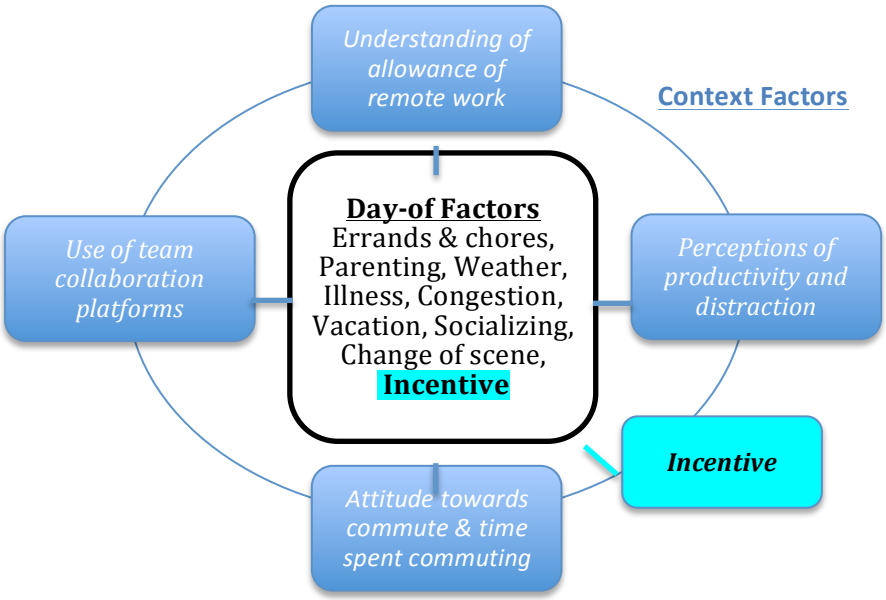
limitations. In using data from the American Time Use Survey, while I was provided with an extremely high quality probability sample of Americans, I had no control over the questions that were asked of respondents, and could therefore not get representative data that spoke directly to topics such as coworking spaces, or the use of mobile cloud platforms, or any particular computing technology for that matter. In conducting my own survey and set of interviews in the New York Metropolitan area, I was able to design my own questions, yet had to rely on a purposive non-probability sampling method. As a result, and particularly because of the uniqueness of the New York Metropolitan area, these latter findings are not easily generalizable to other locations within or without of the United States.

In the historical part of this dissertation, comprising chapters 2,3 and 4, a key limitation is related to the availability of historical documents, including archived websites. There were situations—fortunately few and far between—where I encountered a dead end in trying to track down a particular document, report, book, or web page. Indeed in conducting this research I have become an advocate for the archiving of digital materials in the name of research, such as through the efforts of the Internet Archive project. Overall, I understand that my limited contributions through historical analysis, primary interview research, and the analysis of secondary and primary survey data, provide just one set of studies towards a greater project of understanding these complex topics within society, and that it takes varied approaches from varied researchers to build a strong body of knowledge.

iii. Planning through Telework Under Mobile Cloud Computing

The specific findings of the empirical portion of this dissertation improve understandings of work-related travel behavior by showing how workers make decisions about travel under the influence of mobile cloud computing. Yet, in addition to informing demand modeling, these findings point to greater potential for incentives to play a role in travel demand management (TDM) programs. Telecommuting was an early strategy for eliminating trips in TDM, however implementations tended to focus more on schedule shifts (temporal flexibility), than location shifts (spatial flexibility) (Ferguson 1990). Yet the current context of work location decision-making, which for some workers includes using cloud computing team collaboration platforms across multiple devices, prompts another look at how incentives could be used, especially in regard to spatial flexibility. Incentives to encourage a full day or part day shift in work location might be added to the work location decision-making model provided by this study in chapter 6, either as a context factor or as a day-of decision factor (Figure 13). An example of the former is a long running incentive designed to reduce peak-hour load on weekdays, as have been used in partnership with employers as part of the wider trip reduction efforts discussed in Chapter 3. The latter—what we might think of as "real-time" incentives, could be designed to impact travel on a certain day, such as during a festival, or a certain hour or place based on monitoring of real-time system conditions.

FIGURE 13. Adding Incentives to Work Location Decision-Making



Two examples from recent practice—one transit, one roads—provide examples for how such incentive systems could function. The first example, the 2016 Bay Area Rapid Transit (BART) Perks trial program, was based on software connected to BART's smart card payment system. BART Perks provided incentives to riders in the form of prize contests, to nudge their rides to either side of the peak period. It used a cloud-based platform accessible on a website, which integrated data from the rider's smart card account and supported user groupings such as for friends or coworkers ("Frequently Asked Questions" 2016). The BART Perks program ended in 2017, but had nearly 18,000 signups, an average of 250 customers who shifted commute times each day during the program, and 15 companies that signed up as partners and agreed to encourage flexible work schedules ("Incentives" 2016).

The second example of using incentives to shape travel demand is based on roads traffic, and is founded on the distributed use of a smartphone application. The Metropia

software platform provides a package of travel demand management capabilities to transportation agencies in connection to a mobile smartphone app, which is made available to transportation system users ("Total Mobility" n.d.) . The Metropia smartphone app, which has been used in metropolitan areas in Arizona and Texas, incentivizes drivers to avoid peak travel times, granting them points which can be exchanged for retail gift cards or donations. Results from a study using the Metropia app data indicate that users were willing to adjust their departure times in response to points-based incentives, but that recreational trips were more likely to be shifted, and that the details of the points allocation in response to peak times mattered to outcomes (Arian et al. 2018).

What these two existing incentive systems have in common is that they largely speak to temporal flexibility by trying to incentivize users to delay trips in order to make them more efficient through avoiding traffic. Based on the findings of this dissertation, a greater encouragement of spatial flexibility in addition to temporal flexibility would make incentive programs more effective at favorably impacting travel demand. For example in the case of spatial work flexibility, a worker could start work from home in the morning and delay their departure by hours not just by minutes. In practice, a greater impact on peak travel might be found if a wider window were granted for shifts in travel, and if the messaging to employers spoke to both temporal and spatial flexibility. While both BART Perks and Metropia involve employer partnerships, the message to employers from such programs should be one of permitting flexibility of both schedule and location for those employees for whom it is feasible. In many cases such flexibility from distributed project teams and clients using cloud-based team collaboration platforms may

already exist and just needs to be incentivized in the right way to influence travel demand towards better transportation system outcomes.

Based on the findings of this dissertation, I argue that further research in the area of transportation should be conducted in three broad areas, and hope to participate in this research during my career. Firstly research should seek to improve understandings of how work location decisions are made for project-based workers, especially those participating in virtual teams and other new work styles under mobile cloud computing infrastructure. For example the conceptual model of decision-making in this dissertation could provide the basis for the design of a representative survey in a different city to shed stronger light on this aspect of travel behavior. Secondly on the basis of this first effort, I urge additional research into policy tools that can take advantage of the new found flexibility of some workers in the interest of societal good, both environmental and personal wellbeing. Projects such as BART Perks and the Metropia app provide a start, but a firmer knowledge foundation on work location decision-making under mobile cloud computing would support the design of more effective tools and inform programs that interface with employers. Finally, the issue of equity in access to the flexibility that comes from these new project-based work styles such as virtual teams is lacking at present, even in my own research efforts. Research should therefore be conducted to measure the level of this new inequality and to better understand the experiences of those who lack access to this new benefit, as well as implications for transportation that stem from this inequality.

iv. Computing Infrastructure-Aware Planning in the "Smart" City

How we compute as a society has implications for how we plan as a society. John Friedmann has defined planning as efforts to "relate scientific and technical knowledge to actions in the public domain" (Friedmann 1987). The discipline of planning has long made use of the capabilities of computing in its internal methods, from Lowry's early Model of Metropolis (1964) as discussed in Chapter 2, to the newest advances of computing in support of Geographic Information Systems (GIS). Yet to achieve the aims of planning, planners need to do more than apply science and technology methods in their own internal work processes, they must also be aware of the ways in which advances in science and technology both shape the present context in which they plan, and exert pressure on the alternative futures they hope to support. Computing infrastructure—representing the ways that processing power is enabled, integrated within organizations and accessed by individuals—is an increasingly fundamental part of the scientific and technical knowledge that planners must relate to the public domain, creating both challenges and opportunities for the discipline as it addresses mounting challenges of inequality and sustainability.

While most conceptions of "smart city" imply a role for information and communication technologies (ICT), meanings can vary greatly by author and context. Among large technology firms offering services to cities, the importance of computing infrastructure is evident. IBM refers to the notion of "cognitive computing" in its description of the smarter city ("Smarter Cities" n.d.). Siemens considers the goal of smartness to be efficiency, and see the Internet of Things technology as enabling this efficiency ("Smart Cities" n.d.). Cisco systems similarly points to a role for an Internet of Things, and likens the goal of smartness in a city to the development of a nervous system

which informs both city managers and residents ("What is a Smart City" n.d,). Critiques of these corporate conceptions of the "smart city" cover both its content and the extent to which they exist in practice. Greenfield (2013) points to the controlling top-down orientation of plans for three smart cities as antithetical to the informal and dynamic bottom-up nature of cities. Shelton et al. (2015) draw attention away from the smart city as an complete entity and towards the micro-integration of smartness within existing communities, finding that these integrations are not transformational but are rather subject to familiar political conflicts and unequal outcomes.

Whether participating in city planning in collaboration with technology firms and governments, or in voicing critiques of the "smart city," planners and urban theorists can benefit from an awareness of computing infrastructure. Just as the innovations of mobile cloud computing confronted the problems of portable personal computing, as discussed in Chapter 4, new forms of computing are confronting problems associated with mobile cloud computing, such as the need for constant checking of portable devices to interface with cloud systems in accomplishing activities. Emerging computing infrastructures include the "cognitive computing" discussed by IBM in their vision of the smart city denoting artificial intelligence, to the now-commonplace notion of the Internet of Things envisioned by Siemens and Cisco. The discipline of planning will surely both benefit and face challenges in its own internal work processes through this production of new computing infrastructures. Yet if planners themselves are not computing-infrastructure aware, they miss vital opportunities to shape computing integrations in practice, and weaken their own voice in guiding society towards more just, equitable, and sustainable alternative futures.

Appendices

i. Full Modeling

TABLE 9: Daily Travel Time in Minutes Full Model (US Workers 2003-2017; n=36,176)

	Work-Related Travel Time				*All Travel Time*			
	Coef.	**Std. Err.**	**t**	**Sig.**	**Coef.**	**Std. Err.**	**t**	**Sig.**
Work Location								
Base: Workplace Only								
Home only (n=3,538)	-2.63	0.13	-20.43	***	-0.39	0.03	-11.24	***
Other home only (n=213)	-0.24	0.10	-2.31	**	0.12	0.08	1.54	
Café/library only (n=168)	-0.17	0.11	-1.50		0.31	0.07	4.42	***
Vehicle only (n=128)	2.45	0.07	36.22	***	2.01	0.05	37.90	***
Unspecified (n=875)	0.17	0.06	2.82	***	0.37	0.05	7.98	***
Workplace and home only (n=4813)	0.03	0.02	1.51		-0.03	0.01	-2.41	**
Workplace and other home only (n=192)	0.20	0.08	2.45	**	0.17	0.07	2.40	**
Workplace and café/library only (n=367)	0.33	0.05	6.51	***	0.19	0.04	4.61	***
Workplace and vehicle only (n=244)	1.37	0.07	18.85	***	0.97	0.06	16.13	***
Workplace and unspecified only (n=403)	0.38	0.05	7.17	***	0.35	0.05	7.44	***
Workplace and 2 or more (n=578)	0.67	0.06	11.55	***	0.44	0.04	10.33	***
Home, not work and 1 or more (n=583)	0.82	0.11	7.73	***	0.72	0.07	10.28	***
Employment Characteristics								
Is paid hourly	-0.06	0.02	-3.48	***	-0.02	0.01	-1.92	*
Is part time	-0.13	0.03	-4.55	***	0.07	0.02	4.28	***
Has multiple jobs	0.04	0.03	1.53		0.07	0.02	3.21	***
Self employed	0.05	0.07	0.64		0.04	0.05	0.70	
Is government worker	-0.13	0.03	-3.63	***	-0.04	0.02	-2.09	**
Is nonprofit worker	-0.04	0.04	-1.05		0.00	0.02	-0.23	
Occupations								
Base: Office/admin								
Management	0.02	0.03	0.82		-0.01	0.02	-0.82	
Business and financial	0.10	0.03	3.00	***	0.02	0.02	1.13	

Computer and math. Science	0.07	0.04	1.97	**	0.01	0.03	0.40	
Architecture and engineering	0.06	0.04	1.53		0.02	0.03	0.65	
Life, physical, and social science	0.15	0.12	1.21		0.01	0.04	0.31	
Community and social service	0.01	0.06	0.09		0.01	0.04	0.21	
Legal occupations	0.00	0.06	0.02		-0.01	0.04	-0.30	
Education, training, and library	-0.12	0.05	-2.53	**	-0.08	0.03	-3.20	***
Arts, design, ent., sports	0.03	0.05	0.65		-0.04	0.04	-1.05	
Healthcare practitioner/technical	0.05	0.04	1.21		-0.06	0.03	-2.22	**
Healthcare support	0.07	0.05	1.46		-0.02	0.03	-0.51	
Protective service	0.13	0.11	1.26		-0.05	0.04	-1.30	
Food prep/serving related	-0.19	0.05	-4.02	***	-0.15	0.04	-4.14	***
Building and grounds	0.08	0.05	1.60		0.02	0.03	0.63	
Personal care and service	-0.08	0.07	-1.15		-0.07	0.04	-1.87	*
Sales and related	0.03	0.04	0.90		-0.05	0.02	-2.35	**
Farming, fishing, and forestry	0.07	0.12	0.57		-0.03	0.09	-0.34	
Construction/extraction	0.17	0.05	3.65	***	0.06	0.03	1.79	*
Installation/maintenance/repair	0.07	0.04	1.76	*	0.02	0.03	0.84	
Production	-0.05	0.03	-1.46		-0.05	0.02	-1.87	*
Transportation/material moving	-0.02	0.04	-0.41		-0.09	0.03	-3.37	***
Industries								
Base: Professional and business services								
Agriculture	-0.31	0.11	-2.97	***	-0.13	0.08	-1.67	*
Mining	0.39	0.15	2.62	***	0.14	0.07	2.00	**
Construction	0.19	0.04	4.67	***	0.12	0.03	3.89	***
Manufacturing	-0.06	0.03	-2.22	**	-0.03	0.02	-1.40	
Wholesale and retail trade	-0.04	0.03	-1.31		-0.05	0.02	-2.14	**
Transportation and utilities	0.02	0.04	0.53		-0.01	0.02	-0.35	
Information	0.04	0.05	0.85		-0.01	0.03	-0.40	
Financial activities	0.00	0.03	0.07		-0.01	0.02	-0.50	
Education and health services	0.00	0.03	-0.12		-0.04	0.02	-1.84	*
Leisure and hospitality	-0.03	0.04	-0.73		-0.02	0.03	-0.63	
Other services	0.00	0.06	0.08		-0.08	0.03	-2.59	***
Public administration	0.16	0.06	2.95	***	0.04	0.03	1.27	
Education								
Base: High school or less								
Associates degree	-0.02	0.02	-0.93		0.07	0.01	5.41	***
Some college	0.03	0.03	1.10		0.09	0.02	5.90	***
College degree or more	0.05	0.03	1.72	*		0.02	5.14	***
Family/Demographic Characteristics								
Is married	0.06	0.02	2.66	***	0.00	0.02	0.19	
Number of children	0.00	0.01	0.02		0.02	0.01	3.91	***

Family Income								
Base: Less than 50K								
50K to 100K	0.07	0.02	3.67	***	0.07	0.01	5.62	***
More than 100k	0.08	0.02	3.33	***	0.10	0.02	6.25	***
Is female	-0.03	0.03	-0.94		-0.02	0.02	-1.26	
Race								
Base: White non-Hispanic								
Black non-Hispanic	0.09	0.02	3.91	***	0.09	0.01	6.42	***
Hispanic any race	0.21	0.04	5.85	***	0.09	0.02	5.89	***
Other / Multiple races	0.05	0.03	1.71	*	0.02	0.02	0.87	
Female*number of children	-0.04	0.01	-2.67	***	0.02	0.01	2.62	***
Female*married	-0.13	0.03	-3.98	***	-0.04	0.02	-2.19	**
Age in years	0.00	0.00	1.87	*	0.00	0.00	-0.58	
Location and Time								
In metropolitan area	0.10	0.03	3.46	***	0.07	0.01	4.73	***
State								
Base: Pennsylvania								
Alabama	-0.10	0.06	-1.68	*	-0.02	0.04	-0.38	
Alaska	-0.25	0.11	-2.28	**	-0.19	0.10	-1.84	*
Arizona	-0.08	0.06	-1.41		-0.05	0.04	-1.30	
Arkansas	-0.26	0.07	-3.85	***	-0.11	0.05	-2.11	**
California	0.03	0.04	0.79		0.04	0.03	1.38	
Colorado	-0.06	0.08	-0.74		-0.02	0.05	-0.45	
Connecticut	-0.09	0.06	-1.40		0.00	0.06	-0.05	
Delaware	-0.06	0.09	-0.62		-0.11	0.07	-1.54	
District of Columbia	0.02	0.10	0.16		-0.02	0.07	-0.30	
Florida	0.04	0.06	0.74		-0.01	0.03	-0.43	
Georgia	0.06	0.05	1.06		0.06	0.04	1.58	
Hawaii	0.09	0.15	0.64		0.01	0.07	0.10	
Idaho	-0.18	0.09	-1.97	**	-0.16	0.07	-2.40	**
Illinois	0.05	0.05	0.86		0.02	0.03	0.79	
Indiana	0.02	0.09	0.17		-0.02	0.04	-0.55	
Iowa	-0.28	0.06	-5.06	***	-0.22	0.04	-5.33	***
Kansas	-0.24	0.07	-3.16	***	-0.15	0.04	-3.29	***
Kentucky	-0.15	0.06	-2.37	**	-0.01	0.05	-0.29	
Louisiana	-0.13	0.07	-1.86	*	-0.18	0.04	-4.13	***
Maine	-0.15	0.09	-1.61		0.03	0.10	0.26	
Maryland	0.17	0.06	2.86	***	0.10	0.04	2.56	**
Massachusetts	0.16	0.06	2.59	***	0.09	0.04	2.45	**
Michigan	-0.09	0.05	-1.83	*	-0.04	0.03	-1.42	
Minnesota	-0.08	0.05	-1.65	*	-0.08	0.03	-2.43	**

Mississippi	-0.16	0.07	-2.31	**	-0.08	0.05	-1.60	
Missouri	-0.14	0.05	-2.60	***	-0.09	0.04	-2.66	***
Montana	-0.38	0.10	-3.81	***	-0.22	0.08	-2.57	***
Nebraska	-0.25	0.07	-3.79	***	-0.07	0.05	-1.36	
Nevada	-0.03	0.10	-0.32		-0.06	0.07	-0.89	
New Hampshire	0.06	0.09	0.76		0.06	0.06	0.91	
New Jersey	0.15	0.05	3.03	***	0.07	0.03	2.16	**
New Mexico	-0.31	0.07	-4.38	***	-0.11	0.09	-1.32	
New York	0.14	0.04	3.25	***	0.14	0.03	5.11	***
North Carolina	-0.04	0.05	-0.88		0.05	0.03	1.51	
North Dakota	-0.35	0.10	-3.45	***	-0.35	0.07	-4.97	***
Ohio	-0.07	0.05	-1.60		0.02	0.04	0.49	
Oklahoma	-0.15	0.06	-2.40	**	-0.07	0.05	-1.45	
Oregon	-0.22	0.06	-3.90	***	-0.11	0.04	-2.61	***
Rhode Island	-0.14	0.10	-1.52		-0.02	0.08	-0.20	
South Carolina	-0.10	0.07	-1.43		-0.01	0.04	-0.22	
South Dakota	-0.31	0.11	-2.84	***	-0.27	0.07	-3.96	***
Tennessee	0.01	0.10	0.11		0.03	0.04	0.79	
Texas	-0.04	0.05	-0.89		-0.03	0.03	-1.09	
Utah	-0.15	0.08	-2.03	**	0.01	0.06	0.12	
Vermont	0.35	0.37	0.94		-0.07	0.12	-0.63	
Virginia	0.03	0.07	0.48		0.02	0.03	0.72	
Washington	-0.01	0.05	-0.11		0.02	0.04	0.50	
West Virginia	0.10	0.11	0.97		0.04	0.07	0.62	
Wisconsin	-0.17	0.05	-3.58	***	-0.10	0.03	-2.77	***
Wyoming	0.03	0.19	0.17		-0.03	0.15	-0.21	
Day of Week								
Base: Wednesday								
Monday	0.00	0.02	-0.07		-0.03	0.01	-1.88	*
Tuesday	0.03	0.02	1.23		0.00	0.01	0.06	
Thursday	0.00	0.02	-0.08		-0.01	0.01	-0.36	
Friday	-0.03	0.02	-1.28		0.11	0.01	7.72	***
Year trend	0.00	0.00	2.74	***	0.00	0.00	-2.64	***
Constant	-5.01	3.13	-1.60		10.03	2.20	4.56	
Pseudo R-squared								
		0.0303				0.0128		

*Source: American Time Use Survey; stars indicate significance: * p<0.10; ** p<0.05; ***p<0.01*

TABLE 10: Odds Ratios for Peak Travel Outcome (US Workers on Workday 2003-2017; n=36,176)

(Base: Peak Morning and Evening)	***No Peak Travel***			***Peak Morning Only***			***Peak Evening Only***		
	Odds Ratio	t	Sig.	Odds Ratio	t	Sig.	Odds Ratio	t	Sig.
Work Location									
Base: Workplace Only									
Home only (n=3,538)	38.96	38.23	***	3.62	11.22	***	16.97	30.29	***
Other home only (n=213)	2.65	3.06	***	1.21	0.64		3.20	4.24	***
Café/library only (n=168)	3.95	3.98	***	1.20	0.43		3.64	3.62	***
Vehicle only (n=128)	3.13	2.99	***	1.23	0.47		2.67	2.66	***
Unspecified (n=875)	1.69	2.74	***	0.99	-0.07		2.25	5.26	***
Workplace and home only (n=4813)	1.13	1.33		1.18	2.37	**	1.21	2.61	***
Workplace and other home only (n=192)	0.99	-0.03		0.46	-2.30	**	1.74	1.95	*
Workplace and café/library only (n=367)	0.85	-0.63		0.91	-0.40		1.07	0.27	
Workplace and vehicle only (n=244)	1.52	1.48		1.09	0.31		1.94	2.60	***
Workplace and unspecified only (n=403)	0.58	-1.86	*	0.75	-1.34		0.77	-1.14	
Workplace and 2 or more (n=578)	0.57	-1.93	*	0.85	-0.67		1.94	3.55	***
Home, not work and 1 or more (n=583)	5.41	7.43	***	2.14	3.34	***	5.45	9.01	***
Employment Characteristics									
Is paid hourly	1.63	8.65	***	1.22	4.04	***	1.45	7.12	***
Is part time	1.52	5.61	***	1.82	9.34	***	2.19	11.72	***
Has multiple jobs	0.92	-0.80		0.93	-0.81		1.13	1.38	
Self employed	0.68	-1.48		1.13	0.55		0.68	-1.64	
Is government worker	0.67	-4.13	***	0.86	-2.06	**	0.92	-0.95	
Is nonprofit worker	0.87	-1.36		0.87	-1.70	*	0.99	-0.14	
Occupations									
Base: Office/admin									
Management	1.03	0.26		1.18	1.79	*	1.16	1.59	
Business and financial	0.71	-2.44	**	0.98	-0.20		0.99	-0.09	
Computer and math. Science	1.04	0.30		0.69	-2.57	***	0.91	-0.77	
Architecture and engineering	0.77	-1.35		0.96	-0.26		0.86	-1.04	
Life, physical, and social science	1.10	0.32		1.19	0.92		1.26	1.05	
Community and social service	1.33	1.52		1.47	2.46	**	1.14	0.80	
Legal occupations	0.89	-0.43		1.22	1.02		0.50	-2.97	***
Education, training, and library	1.12	0.84		1.59	4.19	***	1.01	0.06	
Arts, design, ent., sports	1.66	2.81	***	1.10	0.51		1.48	2.17	**
Healthcare practitioner/technical	1.76	4.10	***	2.34	8.18	***	1.38	2.66	***
Healthcare support	2.02	4.30	***	2.09	5.37	***	1.26	1.31	
Protective service	4.53	9.09	***	3.85	8.98	***	2.43	5.36	***
Food prep/serving related	3.05	6.82	***	2.31	5.44	***	2.84	7.17	***

Building and grounds	2.25	6.02	***	1.86	5.04	***	1.50	3.13	***
Personal care and service	2.33	5.12	***	1.76	3.82	***	1.40	2.05	**
Sales and related	1.76	5.34	***	1.69	5.29	***	1.74	5.58	***
Farming, fishing, and forestry	2.20	2.32	**	1.77	1.52		2.53	2.78	***
Construction/extraction	1.29	1.33		1.49	2.65	***	1.29	1.78	*
Installation/maintenance/repair	0.94	-0.44		1.18	1.30		1.08	0.64	
Production	2.52	8.22	***	2.07	6.67	***	2.23	7.56	***
Transportation/material moving	2.85	9.19	***	2.07	6.41	***	2.74	8.95	***
Industries									
Base: Professional and business services									
Agriculture	1.80	1.95	*	1.14	0.39		1.11	0.37	
Mining	1.76	1.77	*	1.46	1.21		1.94	2.56	***
Construction	0.73	-1.71	*	0.76	-1.94	*	1.04	0.33	
Manufacturing	1.71	5.22	***	1.25	2.38	**	1.52	4.58	***
Wholesale and retail trade	1.89	6.16	***	1.14	1.32		1.21	1.97	**
Transportation and utilities	2.28	6.70	***	1.34	2.46	**	1.59	3.93	***
Information	1.85	4.16	***	1.22	1.36		1.01	0.11	
Financial activities	0.76	-2.21	**	0.89	-1.05		0.71	-3.33	***
Education and health services	1.21	1.77	*	1.21	2.04	**	0.90	-1.03	
Leisure and hospitality	2.82	7.55	***	1.49	3.09	***	1.79	4.73	***
Other services	0.97	-0.24		1.12	0.93		0.97	-0.21	
Public administration	1.39	2.15	**	0.83	-1.51		0.98	-0.15	
Education									
Base: High school or less									
Associates degree	0.76	-4.54	***	0.79	-4.29	***	0.84	-3.08	***
Some college	0.59	-6.74	***	0.66	-6.39	***	0.60	-7.44	***
College degree or more	0.56	-5.75	***	0.68	-4.65	***	0.65	-4.98	***
Family/Demographic Characteristics									
Is married	0.91	-1.29		0.94	-0.89		1.06	0.85	
Number of children	0.91	-3.41	***	1.01	0.36		0.91	-3.74	***
Family Income									
Base: Less than 50K									
50K to 100K	0.82	-3.46	***	0.92	-1.66	*	1.08	1.51	
More than 100k	0.77	-3.21	***	0.97	-0.42		1.22	2.78	***
Is female	0.75	-3.60	***	0.78	-3.34	***	0.81	-2.83	***
Race									
Base: White non-Hispanic									
Black non-Hispanic	1.44	5.08	***	1.43	5.57	***	1.13	1.81	*
Hispanic any race	0.98	-0.26		0.97	-0.51		0.92	-1.32	
Other / Multiple races	1.51	3.99	***	1.05	0.46		1.11	1.02	
Female*number of children	0.85	-3.56	***	0.96	-1.18		0.88	-3.02	***

Female*married	0.89	-1.24		1.01	0.10		0.84	-1.97	**
Age in years	1.00	0.73		1.01	2.56	**	1.00	-1.67	*
Location and Time									
In metropolitan area	0.99	-0.16		0.96	-0.65		0.95	-0.83	
State									
Base: Pennsylvania									
Alabama	1.05	0.22		0.95	-0.28		0.98	-0.10	
Alaska	0.36	-2.22	**	0.49	-1.49		0.29	-2.51	**
Arizona	1.15	0.66		0.99	-0.04		1.44	1.92	*
Arkansas	1.06	0.24		1.00	0.02		0.97	-0.13	
California	1.13	0.90		0.94	-0.51		1.27	1.99	**
Colorado	1.20	0.89		0.92	-0.48		1.08	0.43	
Connecticut	1.38	1.37		1.01	0.04		0.91	-0.39	
Delaware	0.82	-0.46		0.96	-0.12		1.61	1.47	
District of Columbia	1.19	0.48		1.01	0.03		0.40	-1.98	**
Florida	1.04	0.28		0.97	-0.27		0.78	-1.72	*
Georgia	1.07	0.39		0.79	-1.50		0.84	-1.11	
Hawaii	1.21	0.49		1.61	1.37		1.94	1.74	*
Idaho	0.59	-1.30		0.97	-0.10		0.73	-1.13	
Illinois	0.99	-0.09		0.88	-0.89		1.15	0.99	
Indiana	0.92	-0.46		1.00	-0.01		1.03	0.18	
Iowa	1.33	1.31		1.11	0.51		1.18	0.90	
Kansas	0.81	-0.93		0.77	-1.26		0.82	-0.87	
Kentucky	0.97	-0.15		0.86	-0.84		1.05	0.24	
Louisiana	0.73	-1.31		0.74	-1.42		0.86	-0.71	
Maine	0.75	-0.69		1.04	0.15		1.01	0.02	
Maryland	1.05	0.27		0.89	-0.66		1.03	0.17	
Massachusetts	0.90	-0.52		1.10	0.60		0.96	-0.24	
Michigan	1.10	0.57		0.85	-1.06		1.05	0.29	
Minnesota	0.91	-0.54		0.86	-0.94		1.03	0.22	
Mississippi	0.82	-0.93		0.91	-0.45		0.84	-0.60	
Missouri	0.86	-0.81		0.91	-0.57		1.04	0.26	
Montana	0.97	-0.10		0.88	-0.40		0.84	-0.49	
Nebraska	0.85	-0.55		0.63	-1.81	*	0.83	-0.73	
Nevada	1.51	1.67	*	0.69	-1.38		1.73	2.34	**
New Hampshire	0.84	-0.52		0.84	-0.62		1.05	0.17	
New Jersey	0.82	-1.13		1.06	0.38		0.87	-0.77	
New Mexico	0.77	-0.87		1.12	0.49		0.92	-0.35	
New York	1.05	0.35		1.11	0.80		1.07	0.50	
North Carolina	0.62	-2.75	***	0.74	-1.91	*	0.77	-1.64	
North Dakota	1.11	0.25		1.00	0.00		0.60	-1.15	

Ohio	0.83	-1.15		0.78	-1.66	*	1.04	0.25	
Oklahoma	0.65	-1.74	*	0.92	-0.37		0.82	-0.88	
Oregon	1.04	0.20		0.91	-0.47		0.93	-0.37	
Rhode Island	1.34	0.63		1.40	1.01		0.98	-0.05	
South Carolina	0.79	-1.11		0.68	-2.21	**	0.92	-0.50	
South Dakota	0.72	-0.80		1.02	0.06		0.67	-1.14	
Tennessee	0.93	-0.40		0.81	-1.22		0.84	-0.96	
Texas	0.83	-1.35		0.86	-1.18		0.97	-0.28	
Utah	1.38	1.35		1.03	0.14		1.08	0.33	
Vermont	0.59	-1.10		0.79	-0.59		0.81	-0.48	
Virginia	0.99	-0.05		0.99	-0.06		0.94	-0.45	
Washington	1.01	0.06		0.84	-1.02		1.10	0.59	
West Virginia	1.13	0.41		0.99	-0.04		1.07	0.25	
Wisconsin	1.35	1.82	*	0.81	-1.34		0.98	-0.10	
Wyoming	0.36	-1.44		0.52	-1.55		1.16	0.42	
Day of Week									
Base: Wednesday									
Monday	1.06	0.88		1.08	1.27		0.99	-0.16	
Tuesday	0.98	-0.30		1.01	0.11		1.00	0.07	
Thursday	1.00	0.02		1.02	0.27		1.06	0.94	
Friday	0.96	-0.59		0.94	-0.92		1.13	1.91	*
Year trend	1.01	2.33	**	1.00	-0.24		1.01	1.48	
Constant	0.00	-2.54		1.53	0.05		0.00	-1.66	

*Pseudo R-Square=.0995; Stars indicate significance: * p<0.10; ** p<0.05; ***p<0.01*

ii. Interview Guide

1. What kind of work do you do?
2. Are you a freelancer or an employee of a company?
3. Does your company have a telecommuting or flextime policy?
    a. Does the same policy apply to everyone? How do you feel about that?
4. Do people in your office work remotely?
5. When was the last time *you* worked from a location other then your main office? This includes your home, a café, coworking space, or any other place.
    a. Why did you decide to work there?
    b. How did it go?
6. How many times did you work from a location other than your main office in the last month?
    a. Tell me about the types of places you worked.

IF REMOTE WORK ONLY

7. How do you decide where to work on a given day? Do you have any choice?
8. How do you get around?
    a. Is distance, travel time or mode of travel a factor you consider in deciding how to work?
9. How does lunch fit into your day?
10. How do you communicate with clients and coworkers when working remotely?
    a. What technologies do you find most valuable?
11. What do you do when you get stuck on some kind of work problem?
12. What do you like most about working remotely?

ALL INTERVIEWEES

13. Do you feel there are any downsides to working remotely?
    a. How about feelings of isolation? How do you cope with that?
14. Do you use your smartphone for work? How so?
    a. What apps do you use most frequently?
15. How about using it to get around, or in deciding where to go?
16. What does your manager/client think about communicating with you remotely?
17. What do you see in your future?
    a. Are you looking to change your current working arrangement?

iii. Survey Instrument

Where do you do most of your work in a typical month? This is work related to your occupation, and excludes school work.

- ○ Office building of employer
- ○ Your home / home office
- ○ Coworking space
- ○ Retail location of employer
- ○ Other (Please describe) _____
- ○ I don't have one regular work location

In a typical month about how many days do you conduct work from _____ but also conduct SOME work from one or more other locations? This would be at least 15 minutes of work conducted from any other location in addition to your office building.

- ○ Never
- ○ 1 or 2 days
- ○ 3 to 5 days
- ○ 6 to 9 days
- ○ 10 to 19 days
- ○ 20 or more days

At what places?

	Never	Occasionally	A moderate amount	Often
My home	○	○	○	○
Office of client	○	○	○	○
Cafe / coffee shop	○	○	○	○
Airport, hotel, or plane	○	○	○	○
Coworking space	○	○	○	○
Someone else's home	○	○	○	○
Vehicle (car, bus, train)	○	○	○	○
Workplace of second job	○	○	○	○
Other	○	○	○	○

In a typical month about how many workdays do you conduct ALL work from one or more locations other than _____? This would be a day where you don't go to your regular office building at all and instead do work from your home, a client's office, a cafe, or any other places.

- ○ Never
- ○ 1 or 2 days
- ○ 3 to 5 days
- ○ 6 to 9 days
- ○ 10 to 19 days
- ○ 20 or more days

At what places?

	Never	Occasionally	A moderate amount	Often
My home	○	○	○	○
Office of client	○	○	○	○
Cafe / coffee shop	○	○	○	○
Airport, hotel, or plane	○	○	○	○
Coworking space	○	○	○	○
Someone else's home	○	○	○	○
Vehicle (car, bus, train)	○	○	○	○
Workplace of second job	○	○	○	○
Other	○	○	○	○

IF COWORKER: Are you a full time, part time, or occasional coworker?

- ○ Full time
- ○ Part time
- ○ Occasional

IF HOMEWORKER: On days when you work from home, for how many hours do you typically work?

	Never	Occasionally	A moderate amount	Often
Less than 1 hour	○	○	○	○
1 to 5 hours	○	○	○	○
More than 5 hours	○	○	○	○

IF HOMEWORKER: At what times of day do you typically do your work from home?

	Never	Occasionally	A moderate amount	Often
Early morning	○	○	○	○
Morning	○	○	○	○
Afternoon	○	○	○	○
Evening / Night	○	○	○	○

IF HOMEWORKER: How important are the following to your decisions to conduct work from home?

	Not at all important	Slightly important	Moderately important	Very important
Easier to focus at home	○	○	○	○
Less stress at home	○	○	○	○
Have excess work	○	○	○	○
Clients, coworkers and/or employer not local	○	○	○	○
Child care	○	○	○	○
Pet care	○	○	○	○
Less/easier travel	○	○	○	○
Parking cost/availability	○	○	○	○
Weather	○	○	○	○
Household chores or errands	○	○	○	○
Illness or medical appt.	○	○	○	○
Other	○	○	○	○

IF HOMEWORKER: When you do work from a coffee shop, for how many hours do you typically work?

	Never	Occasionally	A moderate amount	Often
Less than 1 hour	○	○	○	○
1 to 3 hours	○	○	○	○
More than 3 hours	○	○	○	○

IF CAFEWORKER: How important are the following in your choice of a coffee shop in which to work?

	Not at all important	Slightly important	Moderately important	Very important
Quiet / not noisy	○	○	○	○
High energy / busy	○	○	○	○
Reliable wireless network	○	○	○	○
Presence of others working	○	○	○	○
Quality of food/drink	○	○	○	○
Close to home	○	○	○	○
Other	○	○	○	○

IF COWORKER: You've indicated that you use coworking spaces. How important are the following in your choice of a coworking space in which to work?

	Not at all important	Slightly important	Moderately important	Very important
Quiet / not noisy	○	○	○	○
High energy / busy	○	○	○	○
Reliable wireless network	○	○	○	○
Printing / copying	○	○	○	○
Private office availability	○	○	○	○
Conference room availability	○	○	○	○
Has others in my industry	○	○	○	○
Social or professional events	○	○	○	○
Availability of food or drink	○	○	○	○
Close to home	○	○	○	○
Other	○	○	○	○

To what extent are the following challenges to working remotely?

	Not at all a challenge	Minor challenge	Moderate challenge	Serious challenge
Miss out on socializing with coworkers	○	○	○	○
Harder to collaborate with coworkers	○	○	○	○
Harder to focus on work	○	○	○	○
Harder to access work materials and information	○	○	○	○
Fear of being judged by management or coworkers	○	○	○	○
Loneliness / boredom	○	○	○	○
Blurred boundary between work and personal life	○	○	○	○
Internet or power outlet access	○	○	○	○
Other	○	○	○	○

How important are the following to effective communication with coworkers or clients when you are not in the same location?

	Not at all important	Slightly important	Moderately important	Very important
Email	○	○	○	○
Text chat / text messaging	○	○	○	○
Video conferencing	○	○	○	○
Phone / audio conference	○	○	○	○
Document collaboration (like Google Docs, Dropbox, etc.)	○	○	○	○
Database collaboration (like Salesforce, Constant Contacts, Zoho etc.)	○	○	○	○
Other Cloud Platform	○	○	○	○
Other	○	○	○	○

IF HAS EMPLOYER: Does your primary employer have a telecommuting policy?

- ○ Yes
- ○ No
- ○ Don't know
- ○ Not Applicable

IF HAS POLICY: Does the same policy apply to all employees of the organization?

- ○ Yes
- ○ No
- ○ Don't Know
- ○ Not Applicable

IF HAS POLICY: Which of the following characteristics applies to your employer's telecommuting program? Check all that apply.

- ☐ Flexible work location: employer allows you to choose WHERE you conduct work
- ☐ Flexible work hours: employer allows you to choose WHEN you conduct work
- ☐ Must use special software for telecommuting
- ☐ Must have defined task or measurable outcome during telecommuting hours
- ☐ Must be accessible (ie. by email, phone, etc.) during telecommuting hours
- ☐ Managers have discretion in allowing telecommuting by employees they manage
- ☐ Other(s) _____

IF OFFICE: Where in your office building is your work area?

- ○ Inside a cubicle
- ○ In a shared open space
- ○ In a private room
- ○ Other (Please describe) _____

What best describes the areas in which you live and regularly work?

	Urban (tall buildings)	Urban (short buildings)	Suburban	Small Town	Rural
Where you live	○	○	○	○	○
Where you do most work	○	○	○	○	○

Which of the following transportation options are available in either of these areas? (Choose all that apply)

- ☐ Bus stops
- ☐ Train, subway, or streetcar
- ☐ Convenient parking
- ☐ E-hail/Rideshare (Uber, Lyft, etc.)
- ☐ Street hail taxis
- ☐ Bike lanes
- ☐ Bike share

In a typical month, what types of transportation are part of your commute to and from your regular work location?

	Never	Occasionally	A moderate amount	Often
Walking (more than 1 block)	○	○	○	○
In car alone	○	○	○	○
In car with others	○	○	○	○
Bus or commuter van	○	○	○	○
Train, subway, or streetcar	○	○	○	○
E-hail/Rideshare (Uber, Lyft, etc.)	○	○	○	○
Other taxi or car service	○	○	○	○
My bike	○	○	○	○
Bike share bike	○	○	○	○

IF CAFÉ WORKER: You indicated that you sometimes work from one or more cafes or coffee shops. In a typical month, what types of transportation do you use to commute to and from cafe's or coffee shops from which you conduct work?

	Never	Occasionally	A moderate amount	Often
Walking (more than 1 block)	○	○	○	○
In car alone	○	○	○	○
In car with others	○	○	○	○
Bus or commuter van	○	○	○	○
Train, subway, or streetcar	○	○	○	○
E-hail/Rideshare (Uber, Lyft, etc.)	○	○	○	○
Other taxi or car service	○	○	○	○
My bike	○	○	○	○
Bike share bike	○	○	○	○

IF COWORKER: You indicated you sometimes work from a coworking space. In a typical month, what types of transportation do you use to commute to and from coworking spaces from which you conduct work?

	Never	Occasionally	A moderate amount	Often
Walking (more than 1 block)	○	○	○	○
In car alone	○	○	○	○
In car with others	○	○	○	○
Bus or commuter van	○	○	○	○
Train, subway, or streetcar	○	○	○	○
E-hail/Rideshare (Uber, Lyft, etc.)	○	○	○	○
Other taxi or car service	○	○	○	○
My bike	○	○	○	○
Bike share bike	○	○	○	○

IF OFFICE: In a typical month, how often do you work from home or other remote locations in the morning in order to avoid traveling during morning rush hour?

- ○ Never
- ○ Occasionally
- ○ A moderate amount
- ○ Often

IF HOMEWORKER: On days when you work from home for more than 5 hours in a day, how often do you leave the house? This might be going out for lunch, to run errands, to go to a meeting, to pick up kids, etc.

	Never	Occasionally	A moderate amount	Often
Zero times	○	○	○	○
Once	○	○	○	○
Twice	○	○	○	○
Three times	○	○	○	○
Four or more times	○	○	○	○

IF NOT NEVER: What types of transportation do you use for these trips?

	Never	Occasionally	A moderate amount	Often
Walking (more than 1 block)	○	○	○	○
In car alone	○	○	○	○
In car with others	○	○	○	○
Bus or commuter van	○	○	○	○
Train, subway, or streetcar	○	○	○	○
E-hail/Rideshare (Uber, Lyft, etc.)	○	○	○	○
Other taxi or car service	○	○	○	○
My bike	○	○	○	○
Bike share bike	○	○	○	○

IF CAR: You've indicated that you sometimes drive or ride in a car. Is parking paid or free in the places where you live and work?

	Parking is free	Parking is paid	Not applicable
Where you live	○	○	○
Where you do most work	○	○	○

IF EMPLOYER & OFFICE: Imagine your employer was enrolled in a regional program that encouraged employees to avoid traveling at rush hour by working remotely for part of the day. How likely would you be to participate in such a program?

- ○ Extremely unlikely
- ○ Somewhat unlikely
- ○ Neither likely nor unlikely
- ○ Somewhat likely
- ○ Extremely likely

IF EMPLOYER & OFFICE: Imagine your employer was enrolled in a regional program that encouraged employees to reduce their total travel by working remotely for a full day an average of one day per week. How likely would you be to participate in such a program?

- ○ Extremely unlikely
- ○ Somewhat unlikely
- ○ Neither likely nor unlikely
- ○ Somewhat likely
- ○ Extremely likely

Do you have just one occupation or two or more occupations? An occupation could be a full or part-time job, running your own business, or doing freelance work using a specific set of skills or knowledge.

- ○ Just one occupation
- ○ Two or more occupations

What is your current work status in your primary occupation?

- ○ Employee of an organization
- ○ Freelance or contact worker
- ○ Owner of one person business
- ○ Owner of more than one person business
- ○ Starting up a new business
- ○ Other _____

What category best fits this occupation?

- ○ Architecture and engineering
- ○ Arts, design, entertainment, sports, and media
- ○ Building and grounds cleaning and maintenance
- ○ Business and financial operations

- ○ Community and social services
- ○ Computer and mathematical
- ○ Construction and extraction
- ○ Education, training, and library
- ○ Farming, fishing, and forestry
- ○ Food preparation and serving related
- ○ Healthcare practitioner
- ○ Installation, maintenance, and repair
- ○ Legal
- ○ Life, physical, and social science
- ○ Management
- ○ Office and administrative support
- ○ Personal care and service
- ○ Production and manufacturing
- ○ Protective service
- ○ Sales and related
- ○ Transportation and material moving

How satisfied are you with your current status in this occupation?

- ○ Very dissatisfied
- ○ Somewhat dissatisfied
- ○ Neither satisfied nor dissatisfied
- ○ Somewhat satisfied
- ○ Very satisfied
- ○ Prefer not to answer

IF SECOND OCCUPATION: What is your work status in your second occupation?

- ○ Employee of an organization
- ○ Freelance or contact worker
- ○ Owner of one person business
- ○ Owner of more than one person business
- ○ Starting up a new business
- ○ Other _____

What category best fits your second occupation?

- ○ Management
- ○ Business and financial operations

- ○ Computer and mathematical
- ○ Architecture and engineering
- ○ Life, physical, and social science
- ○ Community and social services
- ○ Legal
- ○ Education, training, and library
- ○ Arts, design, entertainment, sports, and media
- ○ Healthcare practitioner
- ○ Protective service
- ○ Food preparation and serving related
- ○ Building and grounds cleaning and maintenance
- ○ Personal care and service
- ○ Sales and related
- ○ Office and administrative support
- ○ Farming, fishing, and forestry
- ○ Construction and extraction
- ○ Installation, maintenance, and repair
- ○ Production and manufacturing
- ○ Transportation and material moving

How satisfied are you with your current status in this occupation?

- ○ Very dissatisfied
- ○ Somewhat dissatisfied
- ○ Neither satisfied not dissatisfied
- ○ Somewhat satisfied
- ○ Very satisfied
- ○ Prefer not to answer

What is your age?

- ○ 18 to 24
- ○ 25 to 34
- ○ 35 to 44
- ○ 45 to 54
- ○ 55 to 64
- ○ 65 to 75
- ○ 75 and over

- ○ Prefer not to answer

What is your gender?

- ○ Female
- ○ Male
- ○ Other _____

What is your race or origin? You may check one or more boxes.

- ☐ Hispanic, Latino, or Spanish Origin
- ☐ White
- ☐ Black or African American
- ☐ American Indian or Alaskan Native
- ☐ Asian
- ☐ Native Hawaiian or Pacific Islander
- ☐ Other race or origin _____
- ☐ Prefer not to answer

What is your current living arrangement?

- ○ Living with spouse/partner
- ○ Living with other family members
- ○ Living with roomates
- ○ Living alone
- ○ Other
- ○ Prefer not to answer

Are there any children under the age of 18 in your household?

- ○ Yes
- ○ No
- ○ Prefer not to answer

What is the highest level of school you have completed or the highest degree you have received?

- ○ Less than high school degree
- ○ High school graduate (including GED)
- ○ Some college but no degree

- ○ Associate degree in college (2-year)
- ○ Bachelor's degree in college (4-year)
- ○ Master's degree
- ○ Doctoral degree
- ○ Professional degree (JD, MD)

Would you please give your best estimate as to your personal income in the last 12 months?

- ○ Less than $20,000
- ○ $20,000 to $39,999
- ○ $40,000 to $59,999
- ○ $60,000 to $79,999
- ○ $80,000 to $99,999
- ○ $100,000 to $149,999
- ○ $150,000 or more
- ○ Prefer not to answer

Would you also please give your best estimate as to your household income in the last 12 months?

- ○ Same as personal income
- ○ Less than $20,000
- ○ $20,000 to $39,999
- ○ $40,000 to $59,999
- ○ $60,000 to $79,999
- ○ $80,000 to $99,999
- ○ $100,000 to $149,999
- ○ $150,000 or more
- ○ Prefer not to answer

What is the zip code where you live?

_____

If you know it, what is the zip code of your regular workplace?

_____

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