Urban Studies

http://usj.sagepub.com

Telecommuting and the Demand for Urban Living: A Preliminary Look at White-collar Workers

Ingrid Gould Ellen and Katherine Hempstead

Urban Stud 2002; 39; 749
DOI: 10.1080/00420980220119552

The online version of this article can be found at:
http://usj.sagepub.com/cgi/content/abstract/39/4/749

Published by:
SAGE
http://www.sagepublications.com

On behalf of:
Urban Studies Journal Limited

Urban Studies, Vol. 39, No. 4, 749–766, 2002

Carfax Publishing
Taylor & Francis Group

Telecommuting and the Demand for Urban Living: A Preliminary Look at White-collar Workers

Ingrid Gould Ellen and Katherine Hempstead

[Paper first received, November 2000; in final form, August 2001]

Summary. With recent advances in communications technology, telecommuting appears to be an increasingly viable option for many workers. For urban researchers, the key question is whether this growing ability to telecommute is altering residential location decisions and leading households to live in smaller, lower-density and more remote locations. Using the Work Schedules supplement from the 1997 Current Population Study, this paper explores this question. Specifically, it examines the prevalence of telecommuting, explores the relationship between telecommuting and the residential choices of white-collar workers and, finally, speculates about future impacts on residential patterns and urban form.

1. Introduction

With recent advances in communications technology, telecommuting appears to be an increasingly viable option for many workers. Some theorists have speculated that workers will soon choose to conduct all personal and professional activities from their individual homes, rendering the workplace obsolete (Toffler, 1981; Negroponte, 1995; Gilder, 1995; Naisbitt, 1995; Cairncross, 1997). And without workplaces, they argue further, the need for cities will cease. Gilder (1995) states bluntly that cities are simply "leftover baggage from an industrial age".

Despite these dramatic predictions about likely decentralisation, little is known about telecommuting and its relationship to cities and residential location. Using the Work Schedules supplement from the 1997 Current Population Study, this paper examines the prevalence of telecommuting, explores the relationship between telecommuting and the residential locations of white-collar workers (in particular, the extent to which these workers live in less urban locations) and speculates about future impacts on residential patterns and urban form.

2. Telecommuting and Urban Form

It is commonly believed that advances in transport technology, such as the truck, the automobile and the interstate highway sys-

Ingrid Gould Ellen is in the Robert F. Wagner Graduate School of Public Service, New York University, 4 Washington Square North, New York, NY 10003, USA. Fax: 212 995 3890. E-mail: ingrid.ellen@nyu.edu . Katherine Hempstead is in the Center for State Health Policy, Rutgers University, 317 George Street, Suite 400, New Brunswick, NJ 08901–2008, USA. Fax: 732 932 0069. E-mail: hkempstead@cshp.rutgers.edu . *Research support was provided by the Taub Urban Research Center. This material is based upon work supported by the National Science Foundation under Grant No. SBR-9817778, "Information Technology and the Future of Urban Environments". The authors are grateful to Maureen Kilkenny, Jed Kolko, Mitchell Moss, Kathy O'Regan, Amy Schwartz and Rae Zimmerman for helpful comments on an earlier draft and to Aimee Molloy for research assistance.*

0042-0980 Print/1360-063X On-line/02/040749-18 © 2002 The Editors of Urban Studies
DOI: 10.1080/0042098022011955 2

tem, facilitated the suburbanisation of employment. During the 19th century, when the cost of moving people and goods was high, urban areas were quite dense. As the streetcar, commuter railroads and interstate highway system were developed, households could afford to move to outlying and lower-density areas. Jobs followed too, as the development of trucks and extensive highways made transport much cheaper and a central location less critical. Firms could now more easily move to the suburbs to take advantage of lower suburban land costs and to gain access to the new markets developing in the growing suburban communities (Mieszkowski and Mills, 1993).

Several theorists argue that advances in communications technology have similarly fostered suburbanisation, especially of office jobs (Garreau, 1991; O'Sullivan, 2000). They argue that these new communication systems (telephone, fax machines, electronic mail) have effectively lowered the cost of transferring information, making some types of office activity less dependent on face-to-face contact and many office firms less dependent in turn on central-city locations.

This paper focuses instead on residential location, exploring the fundamental question of whether advances in communications technology, and specifically the ability to telecommute, are altering residential location decisions and leading households to opt for more remote, less urban locales. According to one common view, telecommuting will soon become widespread and lead a greater number of workers to avoid high-cost urban living and opt instead for outlying, dispersed residential environments (Salomon, 1985; Pascal, 1987; Castells, 1989; Kumar, 1990; Nilles, 1991; Lund and Mokhtarian, 1994; Gordon and Richardson, 1997; Giuliano, 1998; Shen, 2000).

The opportunity to telecommute can in some sense be viewed as a decline in commuting costs—namely, through a reduction in the number of weekly trips. If a worker travels to her office four times per week instead of five, for instance, her commuting costs will decline by approximately 20 per cent. Thus, a worker could move further away from her job, substituting fewer longer trips for more frequent, shorter ones. At the extreme, telecommuting can completely delink a worker from her workplace and permit a worker to move to or remain in a more rural area or a smaller metropolitan area that she believes offers a higher quality of life.[1]

More formally, we can use the monocentric urban model, originally developed by Alonso (1964), to understand the effect of a decrease in travel costs on locational patterns and the demand for urban living. The model shows how land rents are determined and how they vary as a function of distance from the city centre. According to the model, a decrease in travel costs should generate two changes to the residential bid-rent function. First of all, the decline in travel costs should make the residential bid-rent function flatter. The slope of the bid–rent function is:

$$\partial R/\partial x = -t/L$$

where, R is rent per acre of land; x is the distance from the central business district (CBD); L is the amount of land occupied; and t is the marginal transport cost.

The equation shows that rents tend to decrease with distance from the central city. It also shows that, given a fixed amount of land, a reduction in t makes the bid-rent curve flatter. At the extreme, if urban transport costs were free (i.e. if all employment and services were decentralised), land values would be uniform across urban and rural areas.

The second change generated by a decrease in travel costs is that the bid-rent function will shift out, for the decline in transport costs will effectively result in an increase in income. Assuming land is a normal good, households will demand more land and space and rents will be bid up throughout the urban area. The combination of a flatter slope and a shift out will generate a new bid-rent curve that yields higher rents in outlying areas and potentially lower rents in the central city. The boundary of the urban area will therefore shift out as the demand

for land at the border raises land rents beyond the agricultural rents. A decline in marginal transport costs, that is, should lead to a spreading-out of residential population (Alcaly, 1976; Wheaton, 1977).

Naturally, there are many limitations to this simplified model. Most notably, the model assumes that the workplace is in the central city. Yet, such an assumption is increasingly unrealistic. In 1996, the median employee worked 7 miles from the city centre (Glaeser and Kahn, 2001). For a worker whose workplace is in a suburban area, the opportunity to telecommute may allow her to move farther from her job—to a central-city location. Thus, it is not clear that the decline in travel costs will encourage her to move further out—it will simply allow her to move further from her workplace. For workers in firms based in rural areas, the opportunity to telecommute might encourage them to move to a more urban location. This model is also more difficult to apply to the self-employed, many of whom, as discussed below, are included in our definition of telecommuters.

Shen (2000) models telecommuting as an increase in locational flexibility. Regardless of the location of workplaces, if people can substitute electronic communication for face-to-face interaction, then telecommuting should increase the number of feasible residential locations. This would also seem to predict a furthering of urban sprawl, a pattern that will be reinforced by the fact that workers living in more remote areas may see more to gain from telecommuting. It seems apparent, after all, that middle-class households in the US have used the locational flexibility afforded by transport improvements to move to outlying areas, either to seek larger homes and gardens or to escape urban blight (Mieszkowski and Mills, 1993).

Despite the intuitive appeal of this hypothesis, there are reasons to believe that these technological advances will not in fact lead to such residential upheaval and decentralisation (Gaspar and Glaeser, 1998; Moss, 1998). First, it may be that people will not telecommute on a regular and sustained basis, and thus commuting costs will not be so dramatically reduced. As of yet, relatively few workers have chosen to telecommute full-time (Handy and Mokhtarian, 1995; Wheaton, 1999; Armour, 2001). Even armed with personal computers, fax machines and high-speed cable-modems, most workers still apparently find it imperative to spend time at their office.[2]

Many workers may find electronic communications to be an imperfect substitute for face-to-face interaction (Thrift, 1996; Gaspar and Glaeser, 1998). As useful as e-mail is, for instance, it is not ideal for exchanging complex ideas or transferring skills. As Moss puts it

> firms [still value] face-to-face activities as a means to generate new products and develop new services (Moss, 1998, p. 111).

And this seems especially true for the information-intensive jobs that lend themselves to telecommuting. It is no coincidence that the high-technology industry is the most geographically concentrated in the US (Black and Henderson, 1999). Despite their heavy reliance on up-to-date communications technology, high-tech firms find it critical to locate near to others in similar ventures to share workers, information and ideas. Similarly, Audretsch and Feldman (1996) find that innovative activity tends to be more spatially concentrated in industries with higher levels of R&D expenditure.

Trends in office design—away from individual offices—also suggest a recognition that workplace interaction is, if anything, growing more critical as our economy grows more technologically sophisticated (Davis, 1998; Barta, 1999). In sum, although telecommuting may grow in popularity, workers are likely to telecommute only part-time, or for limited periods of time, and thus the option to telecommute may not radically shift people's residential preferences.[3]

Improvements in communications technology (for example, cable-modems or 'DSL') may lead people to telecommute more intensively in the future. But even if people begin to telecommute full-time, and for lengthy

periods of time, they may still prefer to locate in dense metropolitan regions. Gaspar and Glaeser (1998) point out that electronic and face-to-face communication may in fact be complements not substitutes. As workers use more technology, their networks may grow and they may find themselves *more* reliant on face-to-face interaction—interaction that is naturally facilitated by dense, urban locations. Home workers may also choose to be centrally located to have easy access to airports and business services, such as video conference centres, office supply stores and mail-related services. Finally, there is also something to be said for the importance of simple social interaction. Even if information-sharing across workers is not so critical, workers may still feel the need for human contact. Some studies suggest that telecommuting is quite isolating for most workers (Moss and Carey, 1994; Gillespie *et al.*, 1995). Thus, even if workers do find it possible to telecommute full-time, they may choose to do so in urban settings, where they can easily interact with others.

3. Review of Empirical Research

Although many have speculated about the impacts of telecommuting on residential location choices, remarkably little in the way of empirical work has been done on this subject. For telecommuting to have an impact on residential patterns, two conditions must hold. First, a substantial number of workers must telecommute and, secondly, these telecommuters must have different location preferences from non-telecommuters.

Media estimates of the prevalence of telecommuting vary widely, from a low of a few million to a high of 35 million (McCollum, 1998; Paynter, 1999). As will be discussed further, much of the discrepancy is due to different definitions. For example, some restrict their definition to those who are explicitly paid for work done at home, while others include those who simply bring work home that they were unable to complete at the office.

The most widely cited estimates come from two private consulting firms that conducted annual telephone surveys of 1500–2000 US households. Estimates for 1997 were roughly 11 million for the number of wage and salary workers who are explicitly paid to work at home and over 32 million for the total number of people who report conducting any work at home (McCollum, 1998). These estimates amount to 9 per cent and nearly 27 per cent of non-farm workers, respectively.

As for projections on future telecommuting levels, most sources suggest a strong upward trend. According to one survey firm, the number of wage and salary telecommuters has jumped from 4 million in 1990 to 8.5 million in 1995, 11 million in 1997 and 15.7 million in 1998 (Miller, 1998). Based on these trends, this firm projected that the number of wage and salary telecommuters would reach 18 million in the year 2000. The total number of home offices has meanwhile been projected to climb from 37 million in 1998 to 43 million in 2000 and nearly 50 million in the year 2002 (IDC/Link, 1998). While these estimates lack precision, the overall trend is suggestive. Anecdotal evidence also indicates a growing interest in telecommuting. Ford Motor Company, Intel Corporation, American Airlines and Delta Airlines have all recently announced that they were buying home computers for all of their workers (*Wall Street Journal*, 2000). And surveys suggest considerable interest in telecommuting on the part of US workers (Mokhtarian and Salomon, 1996).

As to the second question—whether telecommuters choose to live in different, and in more outlying, communities—there is only a limited amount of data. To our knowledge, no study has examined the extent to which telecommuters live in or move to less urban locations, which is the very focus of our study. Gaspar and Glaeser (1998) offer some suggestive evidence based on the US experience with the telephone. (One might have predicted, after all, that the telephone would accelerate decentralisation, by decreasing the need for face-to-face communi-

cation.) They find that the pattern of urbanisation in the US from 1840 to 1980 was entirely unrelated to either the introduction of the telephone or its growing use.

The few existing studies exploring the residential choices of telecommuters generally suggest that telecommuting has had only a minor impact on residential choices. One study of San Diego telecommuters found a small number reporting that the opportunity to telecommute was prompting them to consider moves that were two to three times farther away from their workplace (Lund and Mokhtarian, 1994). Nilles (1991) analyses data from a two-year test of telecommuting in California—the California Telecommuting Pilot Project—and compares the actual mobility patterns of telecommuters with those of a control group. He finds no evidence that telecommuters move further from their offices in response to the opportunity to work at home, at least within a two-year period. Only 15 per cent of telecommuters moved during the two-year period and, of these, only half moved further from their central office.

4. Data and Methods

This paper uses a supplemental survey from the Census Bureau's Current Population Study (CPS), a monthly survey of approximately 50 000 households, to examine the geography of telecommuting. The CPS data have many advantages. The sample is drawn nationally and is far larger than those used by previous studies of telecommuting. Additionally, the CPS includes detailed information about occupational and demographic characteristics, as well as data on residence. The existence of these data make it possible to consider spatial aspects of telecommuting, a perspective which has thus far been largely absent from the literature. Using the metropolitan area identifiers on the CPS, we link 1990 census data on metropolitan area size and density to the data-set.

The CPS supplement unfortunately includes no information about the location of one's employer or client-base. Thus, it is important to stress that this paper does not reveal whether workers who telecommute choose to move further away from their place of work. Moreover, since this CPS supplement is cross-sectional and does not include a question on prior residence, it is possible to analyse location, but not mobility. So, while the paper explores whether workers who telecommute are more likely to live in less urban locations, it cannot sort out the direction of causality. Still, whether people move to outlying areas in response to the possibility of telecommuting, or whether people living in these areas work at home to avoid lengthy commutes, a growing opportunity to telecommute may in either case make outlying areas more feasible and desirable places to live in the long run and therefore lead to more decentralisation. Our aim in this paper is to establish the stylised facts.

Defining Telecommuting

For the purpose of this paper, we take as our starting-point the definition from Nilles (1975)—i.e. considering telecommuters to be those who substitute all or part of their daily commute with the use of communication channels. We therefore define telecommuters as workers who are explicitly paid to work at home and who can plausibly be considered to be using communications technology to substitute for time in a workplace.

The CPS supplement asks respondents several questions that allow us to operationalise this definition. First, the supplement asks whether the respondent does any work for her primary job at home. Secondly, it asks whether the worker has a "formal arrangement with her employer to be paid for the work she does at home". With this question, we can restrict our definition to only those who receive payment for their work performed at home. We exclude, for instance, teachers who are finishing lesson plans at home, or workers who take files home that they did not complete at the office.[4]

Thirdly, using the detailed information on occupation provided by the CPS, we include

only occupations in which electronic communication could plausibly substitute for face-to-face communication, eliminating those occupations for which work performed at home must clearly be tangential. Thus we exclude blue-collar workers, as their work at home is rarely a substitute for their core work. Self-employed plumbers and electricians, for example, may schedule appointments from home, but they must travel outside the home to perform the bulk of their work. So, even those who report that they are paid to work at home are not counted here as telecommuters. Workers in farming, forestry and fishing are similarly omitted. Finally, we eliminate certain white-collar professionals for whom physical presence is required. Physicians, for instance, are often on-call from home and may even complete paperwork at home, but they cannot meaningfully substitute electronic communication for face-to-face contact with patients. (This perspective may change if telemedicine becomes more widely accepted.) Jobs in personal and protective services must also, at their core, inevitably involve face-to-face communication.

Unlike many prior analyses of telecommuting (Handy and Mokhtarian, 1995), we include both workers who are self-employed and those who are salaried, since the distinction between these two populations is becoming increasingly nebulous.[5] But for information technology and the opportunity to work at home, many of today's self-employed would probably be commuting to a regular job. In other words, while self-employed workers may not be technically substituting working at home for a commute to an outside employer, they can be considered to be substituting work at home for work at the office over the longer term. We do perform some separate analyses in which these self-employed workers are excluded. Similarly, we also separately analyse 'hard-core' telecommuters, or those who report a relatively large amount of telecommuting (at least 20 hours per week) and those who use both a fax and a modem at home to perform their work at home ('high-tech' telecommuters).

Summary of Data

Table 1 shows that the size of the telecommuting population depends critically on how telecommuting is defined. According to these data, approximately 18 per cent of all

Table 1. Proportion of all persons at work who reported telecommuting in 1997

	Percentage	Standard error	Number of workers (thousands)
Work at home[a]	18.5	0.20	19 400
Telecommuters—paid	8.8	0.14	9 266
Telecommuters—paid (restricted occupations)[b]	6.7	0.13	6 998
Wage and salary telecommuters[c]	2.6	0.08	2 782
High-tech telecommuters	2.3	0.08	2 402
Hard-core telecommuters[d]	1.5	0.06	1 556
Total labour force	100	—	105 050

[a]This category includes all people who report doing any work at home for their primary job.
[b]This restricted definition of telecommuting excludes farmers, blue-collar workers and white-collar occupations such as medicine, personal service and domestic service.
[c]The 'wage and salary' category excludes the self-employed.
[d]The 'hard-core' category includes only those telecommuters who reported working more than 20 hours per week at home.
Notes: Employed persons consist of population aged 16 and over employed in non-agricultural industries. Standard errors calculated with parameters from CPS Work Schedules Supplement Source and Accuracy Statement.

employed persons in non-agricultural industries (or over 19 million workers) reported doing some work at home in 1997.[6] But less than half (8.8 per cent, or some 9.2 million workers) felt that they were explicitly paid to do so. The number falls further when we eliminate those workers who cannot reasonably be thought of as substituting work at home for work and interaction at their office, such as farmers, hairdressers and plumbers. With this restriction, only 6.7 per cent of all workers are engaged in telecommuting.[7] As discussed above, these 7 million workers form the core set of workers whom we define as telecommuters in this paper.

As for the specific sub-sets of telecommuters, we find that salaried telecommuters amount to roughly 2.6 per cent of all non-agricultural workers and self-employed telecommuters comprise about 4.1 per cent. Finally, we find that just 1.5 per cent of non-agricultural workers are 'hard-core' telecommuters, spending at least 20 hours per week at home. These results suggest strongly that telecommuting is a part-time endeavour. Only 22 per cent of the 7 million workers we classify as telecommuters work more than 20 hours per week at home.

It is worth noting that these numbers are all considerably smaller than the estimates of telecommuters reported in the popular press. As mentioned, the press typically relies upon figures generated by a few consulting firms. These firms suggest that over 32 million people worked at home—whether paid or not—in 1997, far higher than the 19.4 million reported here. As for wage and salary telecommuters, the figure most commonly cited is 11 million workers in 1997, or some 9 per cent of all non-farm workers.[8] Using a comparable definition, we find that just 3 per cent of all workers were wage-salary telecommuters in 1997.[9] Given the larger sample size of the Current Population Survey, as well as its careful sampling frame and exhaustive documentation, it seems fair to assume that the figures reported here are more accurate reflections of actual telecommuting activity. As discussed previously, the CPS definition may be somewhat conservative, however, since workers may not interpret their ability to work at home as a formal arrangement with their employer.

Using data from the 1991 Current Population Survey, it is possible to observe trends in telecommuting over the past few years. According to these data, the number of people who reported doing some work from home grew by 7.6 per cent between 1991 and 1997. The share of workers who were *paid* to work at home rose by a much larger 35 per cent. The number of wage and salary workers at home grew faster still over these 6 years—increasing by some 89 per cent over the time-period (Wheaton, 1999).

Table 2 shows some basic characteristics of our sample. The table compares the occupations and demographic characteristics of all non-agricultural workers with those of telecommuters. Specifically, the first column shows the characteristics of all workers, the second column shows the characteristics of 'potential telecommuters' (white-collar workers who could plausibly substitute electronic communication at home for face-to-face interaction in a workplace setting) and the third through the sixth show the characteristics of different groups of telecommuters.[10] The third describes the full set of workers who meet our definition of telecommuters—that is, workers who are paid to work at home and whose occupation means they can plausibly substitute electronic communications for face-to-face interaction in an office; the remaining columns show the characteristics of three more narrowly defined groups of telecommuters—those who are not self-employed (i.e. wage and salary telecommuters), those who use a fax and a modem to work at home (high-tech telecommuters) and those who reported telecommuting more than 20 hours per week (hard-core telecommuters).

As shown, potential telecommuters are more likely to be female, are more likely to be married and to have children at home, and are more educated and affluent than the workforce as a whole. The table also shows that workers who actually telecommute differ in some interesting ways from potential

Table 2. Demographic and occupational characteristics of workers, by telecommuting status

Percentage with characteristic	Non-agricultural workers[a]	Potential telecommuters	Telecommuters: Total	Telecommuters: Wage and salary	Telecommuters: High-tech	Telecommuters: Hard-core
Age-group						
< 30 years	25.13	23.02	10.20	15.26	8.13	7.42
30–39 years	28.05	27.91	27.01	33.74	28.16	28.70
40–64 years	44.11	46.26	56.11	47.49	59.77	60.72
65 or more years	2.71	2.81	6.67	3.51	3.94	2.91
Demographic						
Female	46.68	55.85	46.24	53.00	36.42	40.53
Married	58.24	62.32	74.18	73.00	76.75	71.01
Children at home	22.9	26.07	23.29	28.80	18.04	18.36
Educational attainment						
Less than high school	11.25	4.27	2.89	1.75	0.71	2.78
High school diploma	32.44	25.10	18.46	16.67	14.36	15.18
Some college	28.80	30.37	27.47	27.39	26.06	25.00
BA	18.52	27.00	31.41	35.32	37.08	31.90
MA	6.04	9.64	12.33	13.52	15.20	15.60
PhD/Professional degree	2.95	3.62	7.44	5.35	6.59	9.54
Household income						
< $25 000	23.07	16.20	12.01	10.44	17.78	5.00
$25 000–$50 000	34.24	32.25	26.15	26.52	17.98	23.45
$50 000–$75 000	22.73	25.32	22.64	27.06	23.90	24.02
> $75 000	19.96	26.23	39.20	35.98	40.34	52.47
Race/ethnicity						
White	84.79	86.61	93.64	92.66	94.30	93.88
African-American	10.73	8.77	4.41	4.93	2.85	2.97
Asian	3.62	4.0	2.50	2.23	2.54	2.83
Hispanic	10.09	7.02	3.72	3.99	3.54	4.46
Sector						
Private, for-profit	79.89	75.77	90.22	75.41	95.04	92.69
Private, not-for-profit	5.04	5.86	3.72	9.35	2.36	2.77
Public	15.07	18.37	6.06	15.24	2.60	4.54
Occupation						
Management	14.68	25.26	33.26	27.64	36.06	37.61
Engineering	2.21	3.85	2.70	3.45	3.56	2.42
Computer specialty	1.22	2.13	2.38	3.41	4.08	2.84
Professor	0.64	1.12	1.35	3.40	0.62	0.60
Other professional specialities	8.56	14.96	20.31	18.97	18.62	19.43
Technician	3.34	5.84	2.12	3.74	1.82	2.53
Sales	6.91	12.07	21.19	16.22	24.23	22.18
Retail	5.02	8.78	4.53	3.12	2.96	2.22
Financial	1.77	3.10	3.92	4.14	2.24	1.41
Unweighted frequency	43 987	25 391	3 021	1 163	1 007	656
Weighted frequency (000s)	105 000	60 100	6 998	2 782	2 402	1 557

[a]Includes workers aged 16 and over employed in non-agricultural industries.

telecommuters. They tend to be still older, even more likely to be married, and even more educated and affluent. They are also far more likely to be white and native-born. Perhaps somewhat counter to expectations, the gender breakdown of telecommuters is almost identical to that for all workers, despite the fact that potential telecommuters are far more likely to be female.[11] And telecommuters are less likely to have children at home than potential telecommuters. In terms of occupation, telecommuters are disproportionately represented in management-related occupations, sales and other professional specialties, such as public relations and research-based consulting. Telecommuters are disproportionately likely to work in the private, for-profit sector, due to the large share of telecommuters who are self-employed.

Wage and salary telecommuters are a slightly younger and more female group, relative to the overall population of telecommuters (although they are still less likely to be female than the group of potential telecommuters). They are also somewhat less concentrated in management occupations and sales and more likely to work in the public and non-profit sectors. High-tech telecommuters are much more likely to be male and less likely to have children at home. As for the 'hard-core' group of telecommuters, compared with the overall population of telecommuters, they are more typically male, more affluent and educated, and more likely to be managers.

Methods

Our main interest is in testing whether there is a systematic difference in the location of telecommuters compared with other white-collar workers. Are telecommuters less likely to live in urban areas? To address these questions, we use the geographical information included on the CPS. The CPS indicates the metropolitan area in which each respondent lives and also indicates whether the household lives in a central-city, suburban or non-metropolitan area. Using this information, we can test first whether telecommuters are more likely to live outside cities and/or outside metropolitan areas. Secondly, we can also, by linking Census data to the CPS, examine the kind of metropolitan areas that telecommuters tend to live in, compared with other workers. We use two measures to proxy for the degree to which a metropolitan area is 'urbanised': population size and density.[12] The size of an area's population and its density are certainly not the equivalent. Some metropolitan areas, like Lowell, Massachusetts, have relatively small populations but are quite dense and compact. But we believe that each in its own way is an effective proxy for urban living.

As noted, the limitations of the cross-sectional CPS data make it impossible to pinpoint the direction of causality. Workers living in lower-density metropolitan areas may be more apt to telecommute because they face longer commutes. But again if this is true, in the long run it is likely to mean greater decentralisation connected with telecommuting.

We begin by simply comparing the residential locations of our different categories of telecommuters with those of the workforce as a whole. Do telecommuters appear more likely to live in lower-density, less urban locations? We then estimate several regressions, since the locational patterns of telecommuters may in fact be driven by certain characteristics of telecommuters that are correlated with residential choice. It may be true, for instance, that telecommuters are more likely to live in larger, urban locations, but this relationship may hold simply because telecommuters are more educated and more educated workers are more likely to live in larger, urban locations (Kolko, 2000). Thus, we control for demographic characteristics that we know are correlated with residential choices, such as marital status, children, age and education.

Another issue is the worker's industry. Certain industries are concentrated in large, dense urban areas, and it may be that these same industries are more open to telecommuting (for instance, high-tech industries). If so, this might lead telecommuters to be more

concentrated in larger, higher-density urban areas. Similarly, occupations for which telecommuting is difficult may be concentrated in low-density areas. In analysing location, we therefore control for such potentially confounding characteristics as demographic characteristics, the nature of the worker's occupation, sector, industry and region of the country.

Specifically, we use an ordered, logistic regression to test whether the locational choices of telecommuters differ from those of other workers, after controlling for other factors.[13] The estimating equation here is

$$\mathrm{Log}[\mathrm{P}(y \leq j)/1 - \mathrm{P}(y \leq j)] = \mu_j - \Sigma_k \beta_k X_k - \Sigma_m \gamma_m Z_m - \lambda W - \zeta TEL$$

where, $j = 1, 2, \ldots, J - 1$.

The dependent variable takes on one of J ordered categories.[14] Here, it reflects the extent to which the area in which the respondent lives is 'urban', measured by J categories. X is a vector of demographic characteristics such as age, gender, race, ethnicity, family composition, educational attainment and household income. Industry and occupational characteristics are contained in Z. Dummy variables are included for management-related occupations, engineers, mathematical and computer scientists, professors, technicians and occupations in finance, retail and sales. We also include dummy variables to indicate whether the worker is in the not-for-profit, public or private sector and, for private-sector workers, we include dummy variables to indicate his or her industry. Regional dummy variables are included in W. The key variable here is *TEL*, which indicates whether or not the worker telecommutes (measured by various definitions). A negative coefficient on *TEL* indicates that telecommuters are more likely than other workers to live in less urban areas.

For the dependent variable, we utilise several different proxies to capture the degree of 'urbanism' of the worker's residential location. First, we examine whether telecommuters are any less likely to live in cities (or more likely to live in non-metropolitan areas) by using a three-part dependent variable indicating if the worker lives in a central city, in a suburb or outside a metropolitan area. Here, central cities are deemed to be more 'urban' than suburbs and suburbs in turn are deemed to be more 'urban' than non-metropolitan areas.

Secondly, for those workers who live in metropolitan areas, we also examine whether telecommuters are more likely to live in smaller metropolitan areas. This dependent variable takes on 4 values: less than 250 000 people; 250 000–499 999; 500 000–999 999; and over 1 million people.

Finally, for those workers who live in metropolitan areas, we also examine whether telecommuters are more concentrated in low-density metropolitan areas. A metropolitan area is high-density if its population density is at least 900 people per square mile, medium-density if its population density is between 350 and 900 people per square mile and low-density if its population density is less than 350 people per square mile. In our sample, this breakdown results in a roughly equal distribution of population across categories. To give some examples, Chicago, New York and Jersey City emerge as the three highest-density metropolitan areas, while Yuma, Arizona, Duluth, Minnesota, and Greeley, Colorado, are the three lowest-density metropolitan areas in the sample.

Data are weighted to account for unequal sampling probability with weights provided by the Census Bureau for this purpose. Because we ultimately aim to study the effect of telecommuting on the residential patterns of white-collar workers, we limit the sample to 'potential telecommuters'—white-collar workers in occupations for which telecommuting is plausible.

5. Results

Table 3 presents data on the residential location of telecommuters. Specifically, it compares the geographical distribution of telecommuters with that of the workforce at large and with our universe of potential telecommuters. As shown, there is virtually no evidence here in support of decentralis-

ation. Although telecommuters appear slightly less likely to live in central cities than the workforce as a whole (21.8 vs 23.8 per cent), they are also significantly less likely to live in rural (i.e. non-metropolitan) areas. Their distribution appears somewhat more consistent with, although still significantly different from, that of potential telecommuters. Looking across all types of telecommuters, high-tech telecommuters appear the most urban. Just 7.6 per cent of high-tech telecommuters lived in non-metropolitan areas, compared with 18 per cent of the workforce and 14.8 per cent of potential telecommuters. In other words, high-tech telecommuters are 60 per cent less likely to live in rural areas than the full set of non-agricultural workers. This dramatic difference may be a function of the lack of telecommunications infrastructure in outlying areas (Moss and Townsend, 2000; Townsend, 2001).

In terms of metropolitan area size, the key difference appears for high-tech and hard-core telecommuters. These telecommuters are disproportionately located in large metropolitan areas. Of workers who live in metropolitan areas, 63 per cent live in metropolitan areas of over 1 million people. Of high-tech and hard-core telecommuters who live in metropolitan areas, 70 and 71 per cent respectively live in such large metropolitan areas. The discrepancies are greater still if we consider all workers (and not just those who live in metropolitan areas). Sixty-five per cent of all high-tech telecommuters and 61 per cent of all hard-core telecommuters live in metropolitan areas of over 1 million people, compared with just over half of the workforce as a whole.

In examining the density of metropolitan areas, only hard-core telecommuters appear to have a significantly different and significantly more urban pattern than other workers. Among hard-core telecommuters living in metropolitan areas, 40.2 per cent live in high-density areas (i.e. metropolitan areas in which density is more than 900 people per square mile), compared with 35.1 per cent of potential telecommuters and 33.8 per cent of the total, non-farm workforce.

The regional patterns, although not the focus of this paper, are worth pointing out. The most consistent and notable difference is that all groups of telecommuters appear much more likely to live in the western portion of the US. In future work, we plan to explore this 'west' effect.

In summary, there is no evidence here that telecommuters are apt to live in less urban areas. Instead, we find some evidence to suggest that certain groups of telecommuters are both more likely to live in metropolitan areas and more likely to live in large, high-density metropolitan areas. Perhaps the most interesting information here is that reported for the hard-core telecommuters—the group of workers who in theory should have the most freedom in their locational choice. These workers appear, if anything, even more urban than the larger set of telecommuters. In short, these findings provide no evidence to suggest that an increase in telecommuting—even regular, frequent telecommuting—will have a decentralising effect on residential location.

Multivariate Analysis

It may still be true that telecommuters are more likely to live in outlying areas and in smaller, low-density metropolitan areas after taking other factors into account. As discussed above, some significant differences in locational preferences could be clouded by differences in the characteristics of telecommuters as compared with non-telecommuters, and to the extent that we see a correlation between telecommuting and larger, higher-density metropolitan areas, it might be attributed to other characteristics.

To explore this, we estimated a series of ordered, logistic regressions of the probability of living in more urban locations.[15] In the first set of regressions, the dependent variable is the ordered locational choice of (1) central city, (2) balance of metro and (3) non-metropolitan location. In the second set, the dependent variable indicates metropolitan

Table 3. Geographical distribution of workers, by telecommuting status

Percentage in stated location	Non-agricultural workers	Potential telecommuters	Telecommuters: Total	Telecommuters: Wage-salary	Telecommuters: High-tech	Telecommuters: Hard-core
Metropolitan residence						
Central city	23.84	23.75	21.76	21.22	23.04	24.80
Balance of metro area	45.00	48.51	51.17	52.91	57.08	52.30
Non-metropolitan	17.97	14.82	13.95	13.06	7.59	13.90
Metropolitan, city/suburb not identified	13.19	12.92	13.13	12.81	12.30	8.99
Distribution differs significantly from labour force[a]			**	**	**	**
Distribution differs significantly from potential telecommuters[a]			**	**	**	NS
Metropolitan area size[b]						
100 000–249 999	7.63	7.12	8.17	8.70	7.40	7.03
250 000–499 999	13.15	12.48	11.69	11.19	9.85	8.40
500 000–999 999	16.17	15.59	14.97	15.54	12.60	13.44
1 000 000 +	63.05	64.80	65.17	64.56	70.14	71.13
Distribution differs significantly from labour force			**	NS	**	**
Distribution differs significantly from potential telecommuters			NS	NS	**	**
Metropolitan area density[b]						
Less than 350 people per square mile	35.5	33.9	34.79	35.81	33.91	29.8
350–899 per square mile	30.7	31.0	30.49	33.39	30.47	30.01
900 per square mile +	33.8	35.1	34.74	30.8	35.62	40.19
Distribution differs significantly from labour force			NS	NS	NS	**
Distribution differs significantly from potential telecommuters			NS	**	NS	**

Region of residence						
North-east	20.25	20.61	19.91	20.62	21.51	17.37
Mid-west	23.54	23.47	20.91	19.50	18.33	22.52
South	35.58	34.53	31.26	34.52	30.06	32.49
West	20.64	21.39	27.92	25.37	30.11	27.62
Distribution differs significantly from labour force			**	**	**	**
Distribution differs significantly from potential telecommuters			**	**	**	**
Unweighted frequency	43 987	25 391	3 021	1 163	1 007	656
Weighted frequency (000s)	105 000	60 100	6 998	2 782	2 402	1 557

[a]In all cases, statistical significance is measured at the 5 per cent level. When calculating chi-squared statistics for metropolitan residence, workers who are not identified as living in a city or suburb are excluded. In all cases, the percentage non-metropolitan differs significantly from the workforce. Percentage non-metropolitan also differs from potential telecommuters in the case of high-tech telecommuters (at the 5 per cent level) and wage and salary telecommuters (at the 10 per cent level).

[b]Defined only for the 36 083 workers living in metropolitan areas (unweighted).

Table 4. Summary of ordered logistic regression coefficients

	Type of place[a]	Metro area size[b]	Metro area density[c]
Telecommuter	Positive ($p < 0.1$)	Not significant	Not significant
Wage and salary telecommuter	Not significant	Not significant	Negative ($p < 0.1$)
Hard-core telecommuter	Not significant	Positive ($p < 0.1$)	Positive ($p < 0.01$)
High-tech telecommuter	Positive ($p < 0.1$)	Not significant	Not significant

[a]Central-city location, suburban location and non-metropolitan location.
[b]Metropolitan area population above1 000 000, between 500 000 and 999 999, between 250 000 and 499 999 and less than 250 000.
[c]Metropolitan area density above 900, between 350 and 899 and below 350 persons per square mile.
Note: All models included controls for gender, marital status, presence of children, race, Hispanic origin, nativity, age, educational attainment, household income, region, occupation, sector, industry and self-employment status.

area size (three categories), while in the third set, the dependent variable indicates metropolitan area density (three categories). As explained above, we test for whether telecommuting is correlated with less urban locations, using four different definitions of telecommuting (all telecommuters paid to work at home, wage and salary telecommuters, hard-core telecommuters, and high-technology telecommuters).[16] Control variables include marital status, presence of children, race, Hispanic origin, nativity, age, educational attainment, household income, region, occupation, sector, industry and self-employment status.

Full results are not shown here for these 12 regressions, but it is worth briefly highlighting a few patterns.[17] The coefficients on the demographic variables provide few surprises. Workers who are married and have children are less likely to live in cities, while more educated workers are more likely to live in cities than the less educated. Immigrants and minorities are also more likely to live in cities and urban areas, as are workers in higher-income households.[18] In terms of occupation, several show a suburban or non-metropolitan bias. Managers, engineers, technicians and workers in retail, sales and financial records are all prone to live outside cities. Workers in the public sector appear somewhat more prone to live outside cities and urban areas than those in the private sector. Finally, workers in professional business services are more likely to live in central cities and urban areas, while those in trade are less likely to be found in those areas.

The central result is the coefficient on telecommuting. In Table 4, we summarise the coefficient on the telecommuting variable for all 12 of our regressions. The columns indicate the dependent variable: choice of jurisdiction (central city, suburb or non-metropolitan); choice of metropolitan area size; and choice of metropolitan area population density. The rows indicate the definition of telecommuting employed.

As can be seen in column 1, which considers the ordered choice of jurisdiction, telecommuting is positively and significantly associated (at the 10 per cent level) with the probability of living in a more 'urban' jurisdiction both when we use our broadest definition of telecommuting and when we consider high-tech telecommuters. The coefficient on telecommuting is not statistically significant when we restrict our definition to wage and salary telecommuters or to hard-core telecommuters, however. Once again, that is, we find modest evidence that telecommuters are more prone to live in cities and metropolitan areas. Note that one explanation for this finding is that firms that are more open to telecommuting are themselves more concentrated in central-city and metropolitan locations. To some extent, our regressions control for this by restricting the analysis to white-collar workers and including both occupational and industry control

variables, but more detailed categories might reveal some important spatial patterns. The fact that telecommuters who use a modem and a fax are more likely to live in cities may be due to the greater availability of high-speed access. It is also possible that urban residents are more technologically sophisticated and are therefore more likely to use technology to work at home.

What about the other measures of urbanisation? Again, there is virtually no support here for decentralisation. (Positive coefficients indicate a tendency for telecommuters to live in more urban areas.) When considering whether a worker lives in a large, medium or small metropolitan area, telecommuting appears to make little difference and, if anything, is correlated with living in *larger* metropolitan areas. In the case of metropolitan area density, the results are mixed. In two regressions, the coefficient on telecommuting is insignificant; in one regression it is positive and significant; and in another it is negative and significant.

In summary, the coefficient on telecommuting is negative and statistically significant (at the 10 per cent level) in only 1 of our 12 regressions. In 4 cases, the coefficient on telecommuting is positive and statistically significant, and in 7 cases, the coefficient on telecommuting is not significantly different from zero.

Consistent with the results above, the group of telecommuters that appears most oriented towards large, dense urban areas is the group of hard-core telecommuters—those who most resemble, that is, the popular image of the telecommuter of the future and who presumably have the most freedom in deciding where to live. To give some sense of the magnitude of these results, we calculated predicted probabilities for the metropolitan area density of the typical hard-core telecommuter. Our estimates indicate that the typical hard-core telecommuter living in a metropolitan area has an 11 per cent chance of living in a high-density area, a 25 per cent chance of living in a medium-density area and a 64 per cent chance of living in a low-density area. By contrast, a worker with the identical characteristics who does *not* telecommute has only a 9 per cent chance of living in a high-density metropolitan area and a 68 per cent chance of living in a low-density metropolitan area.

We also did some separate analyses of the location of self-employed telecommuters and found similar results (not shown).[19] These results are again somewhat surprising, given that self-employed telecommuters—like hard-core telecommuters—presumably have considerably more freedom than most workers in deciding where to live. It appears that large, high-density locations attract these workers, perhaps because of the ease of contact with other workers, access to services that are unavailable in less urban areas, or proximity to urban amenities.

6. Conclusion

This paper challenges the conventional belief that widespread telecommuting will accelerate residential decentralisation. Indeed, it finds little evidence that telecommuting will lead to changes in the residential patterns of US households. Current telecommuters appear less likely to live in rural areas and somewhat more likely to live in larger metropolitan areas. As noted, the data used here do not reveal the location of workplaces, so we do not know whether telecommuters live further from their workplaces or their client-bases, in the case of the self-employed. Similarly, the data used here are cross-sectional and thus shed little light on causality. To study more directly the relationship between telecommuting and location decisions, it would be necessary to follow a cohort of workers over time. Still, this paper does present a challenge to those who predict that advances in communications technology will render cities obsolete.

Notes

1. Naturally, a worker could also use the enhanced flexibility to locate closer to the central city.
2. One recent study also suggests that telecommuters often give up and return to conven-

tional workplaces. In a California demonstration programme, half of the participating telecommuters returned to a conventional workplace within nine months of starting (Varma *et al.*, 1998).

3. Workers in the US also change jobs frequently, so they may resist moving too far away from future job opportunities and job networks.
4. It is possible that this may result in an underestimate of the prevalence of telecommuting, since some workers who telecommute may not interpret it as a separate 'formal arrangement', even though they are explicitly substituting work at home for work at the office.
5. Our set of self-employed is again restricted to white-collar workers, and again we eliminate farmers and other workers who are not substituting their work at home for work that would otherwise be done at a workplace.
6. In our analysis of the labour force, we exclude agricultural workers, those who report negative household income, those whose location (metropolitan versus non-metropolitan) is not specified and those who fail to report whether or not they work at home.
7. This figure suggests that 11.7 per cent of white-collar workers in occupations who could plausibly telecommute in fact do so.
8. The 11 million estimate includes 3.4 million contract workers, some of whom might be classified as self-employed by the CPS. To the extent this is true, this estimate suggests that between 6 and 9 per cent of non-farm workers are wage and salary telecommuters.
9. Most of the reports in the press do not explicitly limit their definition to 'information workers', or to those workers who can plausibly substitute communications technology for face-to-face interaction in a workplace. To arrive at a consistent definition for comparison purposes here, we do not exclude any occupations and consider telecommuters to be all wage and salary workers who report that they are explicitly paid to work at home.
10. To define 'potential telecommuters', we used the detailed occupational groups provided on the CPS to exclude all workers in blue-collar and personal service occupations (codes above 26). Additionally, we excluded groups 7 and 8, which include health diagnosing and treatment occupations.
11. Mokhtarian *et al.* (1998) and Mokhtarian and Salomon (1996) find that while women voice stronger preferences than men for telecommuting, they are no more likely to telecommute.
12. For respondents who live in counties with over 250 000 residents, the CPS also reveals the county. We use this data to test whether telecommuters are more apt to live in low-density counties. We do not report on this analysis below, since it yields essentially the same results as the metropolitan area density analysis.
13. We opt for an ordinal logit model rather than a multinomial logit model since a multinomial logit model would not account for the ordinal nature of our dependent variables—which all in some way measure the degree of urbanism of the worker's residential area—and thus would not employ all the information available in that variable.
14. The contrast is always between the probability of belonging to the first up to the *j*th category and the probability of belonging to the remaining categories.
15. Sample is limited to potential telecommuters.
16. When analysing wage and salary telecommuters, we restrict the universe further to potential telecommuters who are employed as wage and salary workers.
17. Full results available from authors upon request.
18. Workers in the west are more likely to live in cities than workers in the north-east and midwest, which may be due to the fact that western cities have more successfully annexed surrounding communities and therefore cover more land.
19. When restricting the sample to self-employed workers, the coefficients on the telecommuting variables typically become larger and more statistically significant.

References

ALCALY, R. E. (1976) Transportation and urban land values: a review of the theoretical literature, *Land Economics*, 52(1), pp. 42–53.

ALONSO, W. (1964) *Location and Land Use*. Cambridge, MA: Harvard University Press.

ARMOUR, S. (2001) Telecommuting gets stuck in the slow lane: working from home loses appeal for harried employes, skeptical bosses, *USA Today*, 25 June, p. A1.

AUDRETSCH, D. and FELDMAN, M. (1996) R&D spillovers and the geography of innovation and production, *American Economic Review*, 86, pp. 630–640.

BARTA, P. (1999) Austin start-ups bemoan lack of hip office space, *Wall Street Journal*, 1 September, p. T1.

BLACK, D. and HENDERSON, V. (1999) Spatial evolution of population and industry in the United States, *American Economic Review*, 89, pp. 321–327.

CAIRNCROSS, F. (1997) *The Death of Distance*. Boston, MA: Harvard Business School Press.

CASTELLS, M. (1989) *The Informational City: Information Technology, Economic Restructuring, and the Urban-regional Process*. Oxford: Blackwell.

DAVIS, P. (1998) Developments: buildings meant to keep them talking, *Wall Street Journal*, 4 November, p. B14.

GARREAU, J. (1991) *Edge City: Life on the New Frontier*. New York: Doubleday.

GASPAR, J. and GLAESER, E. L. (1998) Information technology and the future of cities, *Journal of Urban Economics,* 43, pp. 136–156.

GILDER, G. (1995) *Forbes ASAP*. 27 February.

GILLESPIE, A., RICHARDSON, R. and CORNFORD, J. (1995) *Review of telework in Britain: implications for public policy*. Centre for Urban and Regional Development Studies, University of Newcastle upon Tyne.

GIULIANO, G. (1998) Information technology, work patterns and intra-metropolitan location: a case study, *Urban Studies*, 35, pp. 1077–1095.

GLAESER, E. and KAHN, M. (2001) Decentralized employment and the transformation of the American city, *Brookings–Wharton Papers on Urban Affairs*, 2001, pp. 1–47.

GORDON, P. and RICHARDSON, H. W. (1996) Are compact cities a desirable planning goal?, *Journal of the American Planning Association*, 63(Winter), pp. 95–106.

HANDY, S. and MOKHTARIAN, P. (1995) Planning for telecommuting: measurement and policy issues, *Journal of the American Planning Association*, 61, pp. 99–112.

IDC/LINK. (1998) *Home networking among hottest new technology areas for 1998 according to IDC*. Press Release (www.idc.com).

KOLKO, J. (2000) The death of cities? The death of distance? Evidence from the geography of commercial internet usage, in: I. VOGELSANG and B. COMPAINE (Eds) *Selected Papers from the Telecommunications Policy Research Conference*, pp. 73–97. Cambridge, MA: MIT Press.

KUMAR, A. (1990) Impact of technological developments on urban form and travel behaviour, *Regional Studies*, 24, pp. 137–148.

LUND, J. and MOKHTARIAN, P. (1994) Telecommuting and residential location: theory and implications for commute travel in the monocentric metropolis, *Transportation Research Record*, 1463, pp. 10–14.

MCCOLLUM, T. (1998) A high-tech edge for home offices, *Nation's Business*, December, pp. 52–54.

MIESZKOWSKI, P. and MILLS, E. (1993) The causes of metropolitan suburbanization, *Journal of Economic Perspectives*, 7(3), pp. 135–147.

MILLER, T. (1998) Teleworkers: multiplying fast but elusive to target. Brief 152, Cyber Dialogue, New York.

MOKHTARIAN, P. (1997) The transportation impacts of telecommuting: recent empirical findings, in: P. R. STOPHER and M. LEE-GOSSELIN (Eds) *Understanding Travel Behaviour in an Era of Change*, pp. 91–106. Oxford: Pergamon Press.

MOKHTARIAN, P. (1998) A synthetic approach to estimating the impacts of telecommuting on travel, *Urban Studies*, 35, pp. 215–241.

MOKHTARIAN, P. and SALOMON, I. (1994) Modeling the choice of telecommuting: setting the context, *Environment and Planning A*, 26, pp. 749–766.

MOKHTARIAN, P. and SALOMON, I. (1996) Modeling the choice of telecommuting: a case of the preferred impossible alternative, *Environment and Planning A*, 28, pp. 1859–1876.

MOKHTARIAN, P., BAGLEY, M., and SALOMON, I. (1998) The impact of gender, occupation, and presence of children on telecommuting motivations and constraints, *Journal of the American Society for Information Science*, 49, pp. 1115–1134.

MOSS, M. (1998) Technology and cities, *Cityscape: A Journal of Policy Development and Research*, 3(3), pp. 107–127.

MOSS, M., and CAREY, J. (1994) Telecommuting for individuals and organizations, *Annual Review of Communications International Engineering Consortium*, 47, pp. 324–329.

MOSS, M. and TOWNSEND, A. (2000) The internet backbone and the American metropolis. *The Information Society*, 16, pp. 35–47.

NAISBITT, J. (1995) *The Global Paradox*. New York: Avon Books.

NEGROPONTE, N. (1995) *Being Digital*. New York: Vintage Books.

NILLES, J. (1975) Telecommunications and organizational decentralization, *IEEE Transactions on Communications,* COM-23(10), pp. 1142–1147.

NILLES, J. (1991) Telecommuting and urban sprawl: mitigator or inciter?, *Transportation*, 18, pp. 411–432.

O'SULLIVAN, A. (2000) *Urban Economics*, 4th edn. Boston, MA: Irwin McGraw-Hill.

PASCAL, A. (1987) The vanishing city, *Urban Studies*, 24, pp. 597–603.

PAYNTER, S. (1999) Workplace 2020: what is in store for working mothers in the brave new business world of tomorrow?, *Working Mother*, June, pp. 32–36.

SALOMON, I. (1985) Telecommunications and travel: substitutes or modified mobility?, *Journal of Transport Economics and Policy*, 19, pp. 219–235.

SHEN, Q. (2000) *New telecommunications and*

residential location flexibility. Paper presented at the *Annual Meetings of the Transportation Research Board*, Washington, DC.

THRIFT, N. (1996) New urban eras and old technological fears: reconfiguring the goodwill of electronic things, *Urban Studies*, 33, pp. 1463–1493.

TOFFLER, A. (1981) *The Third Wave*. New York: Bantam Publishing.

TOWNSEND, A. (2001) The Internet and the rise of the new network cities, 1969–1989, *Environment and Planning B*, 28, pp. 39–58.

VARMA, K., HO, C., STANEK, D., and MOKHTARIAN, P. (1998) The duration and frequency of telecenter use: once a telecommuter, always a telecommuter?, *Transportation Research C*, 6(1), pp. 47–68.

WHEATON, W. (1977) Residential decentralization, land rents, and the benefits of urban transportation investment, *American Economic Review*, 67, pp. 138–143.

WHEATON, W. (1999) *Telecommuting: The Real Story*. MIT Center for Real Estate, April.