

Final report of ITS Center project: Telework

A Research Project Report

For the Center for ITS Implementation Research

A U.S. DOT University Transportation Center

TELEWORK

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May 2006

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Executive Summary

Telework holds promise as a potential mechanism to reduce traffic congestion and air pollution, but there are ample disbenefits and barriers to implementing telework. Individual employees must possess the motivation to voluntarily telecommute, and there are numerous social, psychological, and often, economic factors that must be brought to bear before opting to telework. In addition, the interests of businesses and individuals do not always coincide on matters such as telework sites. Employees largely prefer home-based options, whereas businesses may prefer employees to telecommute from a work center under formal telework programs.

Furthermore, some commuters simply will not accept telework; others like commute time to “unwind” or redirect their focus between other activities; and others simply enjoy driving. Although work trips may be shortened, or eliminated, by telecommuting, travel and trip making continues. Trip generation and distance is partially determined by gender, household responsibility, presence of children and income. These are factors that are largely unalterable.

Finally, suburbanization of employment and residences contributes to the shape of the modern urban form. Telework options may promote continued dispersion and complex travel patterns as persons move further into remote areas, which may or may not be desirable from a planning perspective.

Videoconferencing. The early optimistic forecasts that videoconferencing would provide, in a very short space of time, a popular and widely used telecommunications instrument for business that would reduce the need for travel to face-to-face meetings were not well founded. In

particular, such predictions ignored, on the supply-side, the inherent limitations of the infant technology available, the socioeconomic difficulties of converting to the new media and the high costs of use while, on the demand-side, the capacity of conventional transport modes still provided reasonably reliable and efficient means of facilitating face-to-face contacts.

These forecasts also ignored the possibility of other new technologies that would find a market niche much more rapidly, such as the facsimile, and have tended to divert resources away from videoconferencing. One must also add that the external benefits often derived from business travel (visiting new places, making new acquaintances and being out-of-the-office) may well have been underestimated in these predictions. As a result, the diffusion of teleconferencing has been slower than expected.

New land patterns. Telework may well contribute to long-term changes in land use patterns, but history shows that such changes are slow to occur and difficult to forecast.

TELECOMMUNICATIONS AND TRAVEL BEHAVIOR

INTRODUCTION

Many in transportation management are looking to telework as a means of providing an interim, less costly and fairly expeditious way of reducing traffic congestion and traffic related pollution; the 'intelligent transportation approach'.¹ Generally, it is believed that telework has the potential to eliminate or otherwise shorten work commutes during peak travel times since with telework, employees work from home or travel to nearby work centers. Such options provide individuals with increased control over work and family requirements, and provide employers benefits such as lower costs, increased employee morale, and higher productivity.

There has also been interest from the policy perspective in the role that teleworking and the like may play in reducing the environmental costs of transportation, and in particular the pollution associated with the automobile. Cars both create a large amount of environmental damage and produce a diverse range of harmful effects that, it is often argued, require a range of policy options to combat.² Whilst not a direct means of internalizing these social costs of transportation by affecting the amount and nature of personal and goods movement it is felt that telecommunications policy may have desirable effects on the problems of traffic and the environment.

¹ For a significant study of the issues involved in the US see US Department of Transportation (1992).

² As pointed out in Chapter 2 within the industrial countries, transportation accounts significant nitrogen oxide emissions (an 'acid rain' gas), carbon monoxide emissions (a toxic gas), particulates (that can be carcinogenic), hydrocarbons (that are the main contributors to 'global warming'), as well as being noisy and visually intrusive.

Telecommunication advances have created ranges of ‘teleprocesses’ that afford the development of varied work methods and arrangements for individuals and firms alike (Nilles, 1994). Teleprocesses encompass teleservices (online banking and shopping), but also include telework. Telework is a term that is used quite loosely and has a variety of definitions – the scope of which is either very broad or very narrow. In the literature the term ‘telecommuting’ is used more frequently. Internationally, however, ‘telework’ is the more common term. In Europe, telework is a slightly broader concept than telecommuting and refers to work performed from distant locations and does not necessarily substitute for the journey to work.

Nonetheless, telework is generally understood to involve ‘using telecommunications to conduct business at a distance and includes videoconferencing, online database searches, facsimile transmission, cellular [and standard] phone calls, voicemail, and electronic mail’ (Handy and Mokhtarian. 1995). Technically, telecommuting is a subset of telework; it eliminates or reduces the length of commute trips because work is completed at home or in telecenters; and has direct transportation implications (Mokhtarian, 1991). Here, the terms telework and telecommunications will be used interchangeably. The definition of telework undergirding this book refers to:

company/government employees in any occupational group working full- or part-time for whom the commute to work is eliminated, shifted out of peak commute times, or shortened through the performance of the work role at home or at an alternative work center, and who communicates with the usual place of work using electronic, tele/videoconferencing or other means instead of traveling there.³

³ Adapted from the definition used by the US Bureau of Transportation Statistics (1993). The definition excludes field workers who travel in the course of work and self-employed, home-based workers, private consultants and contract workers.

COMPLEMENTS OR SUBSTITUTES?

One of the primary reasons behind the push for the increased investigation of telework options is the belief that telecommunication advances will function as a substitute for travel, or affect travel behavior in such a way that peak period congestion is reduced. There is, however, no accepted consensus on the exact nature of the links between telecommunications, and especially teleworking, and transportation use. Two basic hypotheses have been proposed to describe the dominant potential relationship. These are related to notions that information systems may be a substitution or a complement to travel.

Concepts of complementarity and substitutability

Mokhtarian (1997) points out that, 'Historically, transportation and communications have been complements to each other, both increasing concurrently, rather than substitutes for each other. And we have no reason to expect that relationship to change'. But this is not a view all share, and empirical testing is difficult.⁴

Complementarity is, for ease of analysis, commonly discussed in specific terms of enhancement and efficiency, although in practice complementarity is essentially a hybrid of the two.

⁴ There have been studies looking at such things as telephone usage and travel that have sought to isolate the substitution and inducing effects of telecommunications on travel. Micro studies of this find a combination of substitution and complementary effects but the ratio seems to be very contextual (Claisse and Rowe, 1993)

In the case of enhancement, communication stimulates the need or incentive for travel by precipitating the transfer of additional information, specifically information about available opportunities. A brief e-mail, for example, may spark one to identify relevant information (that may or may not involve transportation) on a completely different project. This type of cross-fertilization, synergy, or enhancement is more likely to occur now, purely as a result of the permeability, magnitude, and timeliness of information flows made possible by technology.

An example commonly used to illustrate enhanced efficiency is in freight transportation, where communications technology makes the supply chain more 'transparent' and, therefore, assists efficiency of scheduling and customer service. In personal transportation, an individual may choose to telework in the morning, avoid the morning peak period of traffic congestion, and drive to work later in the day attending business meetings en route. It is argued that the person's efficiency is improved.

Until recently, substitution has been the more popular of the hypotheses, and one that has been taken on board by many politicians and a painless way of tackling traffic congestion. Salomon (2000) succinctly outlines the theory of substitution with regard to transportation and telework; an increase in the supply and use of telecommunications will result in a diminishing demand for transport services. He asserts, however, that there is little evidence to support substitution. He states, 'Consumers are likely to make their choices on the use of either travel or telecommunications on the basis of which mode better serves their ends.'

Thus, instead of substitution, a more plausible telecommunication-travel relationship is that of travel modification. According to the theory of modification, the availability of

telecommunications will modify the demand for travel but not in one unique direction. The realities of the impacts of past communication advances (i.e. the telephone⁵ and facsimile), and present research, supports modification of travel patterns with respect to telework.

A complicating factor of the substitution hypothesis is an assumption that the total volume of interactions, whether by travel or communication (e.g., interactions between people or between workplace and employee) is constant.⁶ This assumption may not be the case (Albertson, 1977). The Institute pour Frantide shows a gradual increase in passenger transport miles and the number of remote communications in France between the early eighteenth century and late twentieth century. Also in practice, the policies adopted regarding the way the transportation system used and the way teleworking is treated by companies and government, for example regarding tax incentives, will be influential on the level of teleworking adopted.

Supporting this hypothesis, over time the aggregate amount of all forms of communication has increased. Incomes have risen, car ownership has risen, and socioeconomic life of western economies has evolved to encourage greater levels of interpersonal contact. High growth in the service sector and information industries, for example, has resulted in a greater inherent emphasis on face-to-face communication and the development of interpersonal relationships during work hours.

Drawing on the ideas of Sviden (1983) a more complete picture seems to be, therefore, that the interactions between telecommunications and transportation have potentially three

⁵ For an analysis of the effects of standard telephones on travel see Claisse and Rowe (1993)

⁶ Nilles (1994) points out, for example, that as the independent demand for telecommunications grows, opportunities for travel substitution and travel stimulation emerge simultaneously. Given this, a clear trade-off between travel and telecommunication seems unlikely.

dimensions. In some cases there is complementarity with advanced communications stimulating teleworking, in other cases there is substitution, but in the third case it may stimulate additional interactions involving both some substitution but also some additional travel (Figure 4.1)

The links are thus not always clear and are often more complex than is sometimes assumed. Increasingly, business and pleasure are merging, and networking is a valued skill in contemporary working life. The complexity of social, economic and technological forces can be such that a firm's success frequently depends heavily on continuously adaptive organizational interactions or networks. This can be particularly so in the case of political and social complexity where a meeting face-to-face may be more desirable than a telephone, videoconference or e-mail interaction. Individuals may be more comfortable discussing the complexities and or sensitivities of a project or process in person. The availability of multiple modes of communication, personal and electronic, enhances the range of opportunities for interaction.

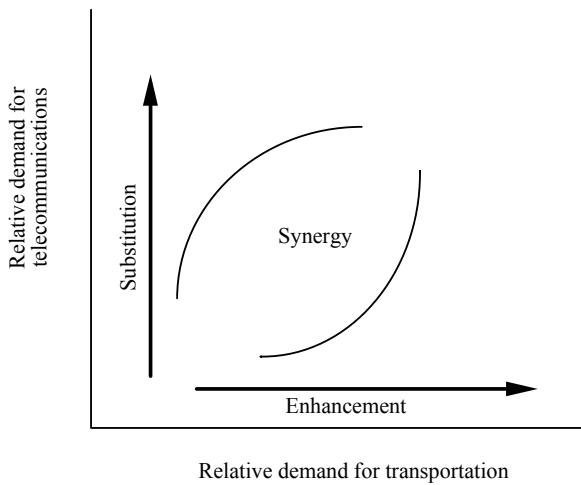


Figure 1 Substitution, enhancement, and synergies

The nature of work

The degree to which telecommunications acts as either a substitute or a complement for transportation will change over time as the nature of work itself changes. The idea of what work entails has historically undergone change as economies have shifted through the centuries from agriculture, heavy industry, manufacturing to an information/knowledge era. We are now moving into a global economic environment. Sullivan (1999) compares the traditional work relationships that generally existed to ‘boundaryless’ or more individualist career paths that exist today (Table 1.1).

Table 1.1 Comparison of traditional and boundary less careers

	Traditional	Boundaryless
Employment relationship	Job security for loyalty	Employability for performance and flexibility
Boundaries (employers)	1 or 2 firms	Multiple firms
Skills	Firm specific	Transferable
Success measured by	Pay, promotion, status	Psychologically meaningful work
Responsibility for career	Organization	Individual
Training	Formal program	On-the-job
Milestones	Age-related	Learning-related

The locus of control for work and career paths has shifted from the company to the individual. Similarly, telework options increase the levels of autonomy and responsibility for employees. Technological advances and globalization, both of which create the need to use

flexible scheduling and work options to meet global service and personal needs, enhance the practicality of telework alternatives for businesses and individuals alike (Lobel et al, 1999). Also, telework is the type of work arrangement that influences individual outcomes like work–family balance, job satisfaction and stress, as well as organizational outcomes like worker morale, productivity, and commitment (Sullivan, 1999). Thus, telework has the potential to further influence the nature of work.

The components of telework’s influence on the nature of work are reflected in, amongst other things, increased use of flexible work hours, satellite offices, innovative monitoring systems, and alternative office arrangements like ‘hoteling’. Hoteling involves reducing the number of private offices and having employees share or reserve office space only when a workspace in the primary office is needed (Saveri, 1995) while they work at home or are at meetings elsewhere for the rest of their work time. The influence of telework also involves aspects of social connectedness/cohesion as well as several dimensions of trust.⁷

Fukuyama (1996) suggests that the social interaction of workplaces is an important element of fostering a sense of community over individualism. He contends, ‘Work and money are much more important as sources of identity, status and dignity ... This kind of recognition cannot be achieved by individuals; it can come about only in a social context.’

Teleworking does interfere with this ‘community building’ process, if only modestly at this juncture. It can also be said that telework adds a dimension of uncertainty that may not bode well for trust within an organization as ‘trust reduces social complexity by going beyond available

⁷ Salomon and Salomon (1984) and Shamir and Salomon (1985) offer some insights into the employees’ perspectives on teleworking.

information and generalizing expectations of behaviors in that it replaces missing information with an internally guaranteed certainty, (Blois, 1999). Diminished levels of face-to-face interaction may reduce trust among managers and staff. Significant increases in the levels and penetration of telework may, however, pose threats to social stability via reduced levels of social capital and shared norms. The reduction in social interaction may create problems for some workers, but not all necessarily.

However, if the costs of videoconferencing equipment and the like diminish, then perhaps teleworking will not have a negative impact on community building or a shared organizational culture. If organizations develop formal strategies to promote the use of videoconferencing and other means of keeping teleworkers ‘connected’ socially, then a new form of organizational communication may emerge that helps to foster trust instead of diminishing it. The additional communication outlet may help promote increased levels of informal social interaction and cohesion.

Fukuyama (1999) contends that in the case of Silicon Valley informal social networks within the various flat, loosely structured organizations facilitated trust and its economic boom. Therefore, employees themselves may find informal ways to maintain social connections despite being physically separated from the work– place. Also, reconnecting work and home may have positive benefits. Fukuyama states, ‘...it is if anything more natural and more in keeping with the experience of human beings throughout history that home and work should be co-located’. With respect to identity, telework may help to ‘regenerate’ some of the family and community norms that have been on the wane.

Giving workers the flexibility to manage their work and family requirements may in the very least reduce stress and improve dispositions and interpersonal interactions. Nonetheless, these types of social and psychological issues are complex and need to be evaluated carefully as there is uncertainty regarding the direction and level of telework's impact at this juncture.

Expanding interactions

Improved and novel transportation technologies, together with additional transportation infrastructure and hardware, have allowed personal interactions to grow considerably over time. These developments, coupled with new demands stemming from changing behavioral patterns have permitted more frequent interactions between the same individuals or groups (a 'deepening effect') and for a larger number of interactions among different individuals (a 'widening effect').

In practice, however, at any point in time there are physical and logistical constraints on the capacity of individuals to meet face-to-face; the transactions costs, to use the jargon of institutional economics, can be very high. This constrained interaction curve is shown graphically in Figure 1.1. Public concerns about the environmental implications of further infrastructure expansion and the high financial costs of such investments, combined with changes in life-styles, suggest that this interaction curve is now beginning to flatten in many countries. It is becoming more difficult and costly to meet face-to-face. Questions can also be raised concerning the marginal social utility of additional transportation infrastructure provision, especially if it leads to additional travel.

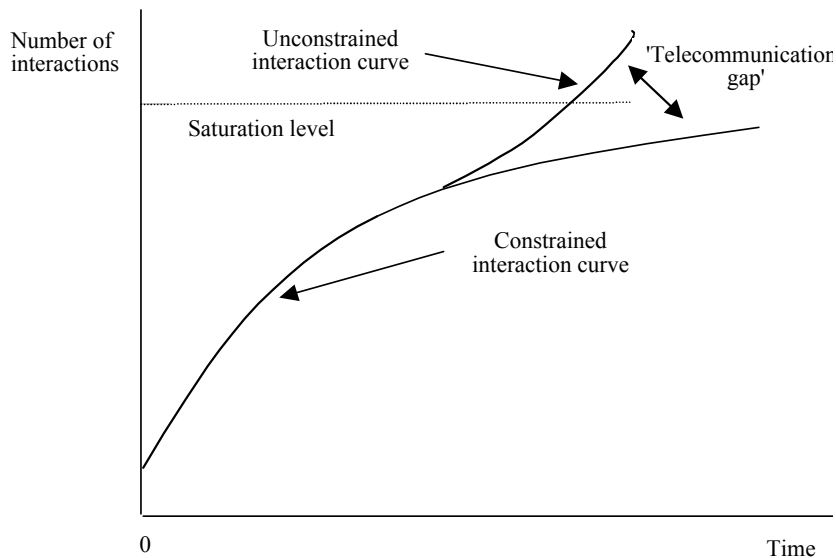


Figure 1.1 The constrained interaction curve and telecommunications

Through telecommunications technology a greater number of interactions are possible because of the empowerment provided through timely (in some cases real-time) information transfer (the unconstrained interaction curve in Figure 4.2). This development means that telecommunications has the scope to not only fill the potential interactions, but also to push up the unconstrained curve. What types of interactions are most efficiently replaced by telecommunications in this process is by no means certain.

Factors affecting interactions

An important factor affecting the nature of human interactions is the complexity and security of the information that has to be transferred. In general, the more complex and sensitive the

information, the more important is the need for face-to-face contact. There is also the uncertain issue of the additional amount of interactions that are generated by the very existence of new forms of interaction. What is currently evident is that people are engaged in a wider range of interactions than before and that the net effect is a greater number of interactions in total.

It is useful in looking at the link between telecommunications and transportation to review the sociological context within which personal transportation take place. Much of the early modeling of travel patterns was essentially aggregate in nature and engineering driven. While more recent work has been more closely allied to behavioral types of models, often based in microeconomic theory, it is still in many ways very simplistic. In particular it has traditionally been assumed that people travel to work just to earn an income. Other motivations for making these types of trip are now seen as important and can impact on travel patterns.

The journey-to-work, and the associated traffic congestion, has been at the center of debates on urban transportation policy. Because road space is publicly owned and not provided in a market setting, and consequently road users are not made fully aware of the full costs of their actions on others at the time trips are made, there tends to develop excessive levels of commuter congestion. Excessive congestion is seen as inefficient in a purely transportation sense and, because of the pollution generated, is often an environmental issue. Considerable research and policy-based analysis has been expended seeking a socially acceptable way of limiting the

congestion problem.⁸ Recent analysis suggests, however, that the issue may be more complex than is traditionally thought.

In much of the transportation and communications discussions, there is the implicit assumption that individuals wish to reduce their travel time, and in particular that involved in the journey-to-work. This has stemmed, in part, from the notion that travel is largely a derived demand existing for the sake of other ends (e.g., to earn an income, shop, transport children or socialize), rather than being an end in itself.

Research in California challenges this assumption, drawing on the findings of a survey of over 1,300 workers that found that only 3% of people desired a zero-to-two minute commute. It showed that almost 50% of respondents preferred a commute of 20 minutes or more. This type of finding would not be inconsistent with the notion of the constant travel budget hypothesis that some traffic engineers have long supported. Such an amount of time spent in traffic congestion may be seen as a reasonable price to pay for a suburban life-style.

Policy makers and researchers focus on the negative impacts of the commute in terms of environmental impacts, congestion, stress and so on, while the positive attributes are not recognized. It can be argued that individuals often value the transition between home and work and the ability to use the time productively. They may also value the opportunity to drive a status-oriented automobile or the chance to experience the sites by traveling. They may value a

⁸ Ideally many economists would privatize the road network giving explicit property rights to the owners. This would stimulate them to ensure the facilities are used optimally. Failing this, a congestion charge could be levied (the 'Road Price') that would lead to a congestion level acceptable to the public authorities being achieved. In practice, however, efforts to contain congestion have involved a combination of subsidies for public transit, physical traffic management schemes and adding additional road capacity. Continuing high levels of traffic congestion are the result.

non-home destination for work because of the social/professional interaction opportunities it affords, the scenic location, or the shopping and other location amenities. There are also the opportunity benefits involved in not spending time in a commute such as doing household chores.

Various pressures and constraints appear important for individuals to change their prevailing work routine. In the majority of cases, a threshold level of dissatisfaction with one or more aspects of life was necessary to cause an individual to consider an alternative to conventional work patterns. This dissatisfaction may be manifest in a desire to accomplish certain goals in work, family, leisure or travel.

Constraints could also be manifest in the amount of telecommuting permitted by the nature of the job or by the employer, the availability of suitable remote technology, whether supervisors support telecommuting, and the propensity toward distractions at home. Individuals are likely to be more productive if they are easily able to switch off from, and separate, home duties.

Interest has grown in the travel patterns of the genders, particularly the apparent idiosyncrasies of travel by women. More part-time work, increases in female non-home based travel, partly through a greater proportion of women in the workforce, and flexible employment have contributed to increased demand for off-peak travel. Women remain responsible for the majority of household duties and child care and this leads to more complex travel patterns involving linked trips and greater car dependency. The flexibility, and complementarity, provided by teleworking is likely to be valued by women, particularly those with dependants.

Employers may find benefits in stimulating or facilitating teleworking. The current relatively strong economy in the US, even in the early 2000s, favors employees. Employers, particularly in the information technology sectors experience difficulties retaining high-quality staff, resulting in valuable expertise and tacit knowledge walking out the door. Employers are often creative in terms of the remuneration packages that they offer, but they also need to provide and manage the work environment. More subtly, telecommunications provides the advantage of impersonalizing communication. It may be more advantageous to employers to use telecommunications to emphasize content and minimize social influences, and to reduced socio-emotional communication and increased task orientation that can enhance group work and efficiency. The success of this effort depends on the context and environment in which the telecommunications mediums are used.

According to some psychologists, the interpersonal attraction dimension of social influence is a multidimensional construct, comprising task attraction, physical attraction and social attraction. The more people are attracted to one another, the more they will communicate with one another. But the more they are attracted to another person, the more influence that person has in interpersonal communication. Interpersonal attractiveness can thus enhance communication and detract from it. Strategically employers could use either telecommunications or face-to-face methods depending on the individuals involved and the company's objectives. It provides employees with more options.

From a financial perspective, employers have identified benefits from savings in office space, lighting and utilities by outsourcing to one-person businesses. In some cases, new office

buildings are being designed on the premise that workers will ‘rent’ rather than ‘own’ space, that is; they will have no dedicated desk, but book one when they need to visit the office (hot desks). Estimations of savings are, however, scant.

In summary, the benefits to employers are largely idiosyncratic, depending on the circumstances and environment of each firm. Transition costs may be large and they are also likely to vary according to the current working practices and fixed investments of firms. Changing working practices is not cost-less and can be disruptive in terms of meeting customer demands.

TRENDS AND REALITIES FOSTERING INTEREST IN TELEWORK

The potential for teleworking

Teleworking can take a number of different forms. Exact delineation is difficult but there has been a convergence to some standard classification. In the US telework options exist in two basic forms (US Bureau of Transportation Statistics. 1993):

- *Home-based.* Employee works at home 1–2 days/week and spends the rest of the week at the main office or other facility;
- *Regional centers/workcenters* – These centers serve as extensions of the normal workplace, but are located closer to employees’ homes, in less congested areas or near public transit locations. Regional centers exist in three primary forms:

- (i) *Satellite workcenters* – These centers are established and equipped by an organization to accommodate its teleworking staff;
- (ii) *Local work centers* – Teleworkers from different organizations use these facilities and share office space/equipment
- (iii) *Neighborhood work centers* – These are smaller centers that serve fewer workers, but generally are located within walking distance of employee residences.

Typically, information or knowledge-based jobs are more suitable for telework. That is, jobs where workers' primary activity involves the creation, processing, manipulation, or distribution of information. McCloskey and Igarria (1998) note that within this context, both jobs with a high division of labor and external control (clerical) and a low division of labor and internal control (professional or managerial) are amenable to telework. According to Nilles (1988), jobs or tasks that are not location dependent and/or do not require significant levels of face-to-face interaction, are likely to be good candidates for telecommuting. Korte and Wynne (1996) suggest the following are possibilities for teleworking:

- Data entry or typing
- Programming or other specialist computing
- Secretarial or administrative work
- Translation
- Financial services, book-keeping or accountancy
- Ordering, information or booking services
- Sales, marketing
- Editing
- Research, consultancy

- Design, architectural work
- Training, education
- Management
- Repair, maintenance.

The up-take of teleworking

As seen in previous chapters, the amount of teleworking still varies considerably from country to country, and also inevitably within countries. But there is, nevertheless a steady growth in its adoption that extends across virtually all countries. Table 4.2, for example, reports the growth in teleworking within the European Union in the 1990s. Although the data are not strictly comparable across years, inverse levels of utilization are clear but so is the overall positive growth path.

Table 1.2 Teleworking in EU countries

Country	Level of teleworking – formal and informal		
	1994	1997	1998/9
Austria	0.35	1.50	2.00
Belgium	0.48	5.30	6.20
Denmark	0.37	9.70	11.60
Finland	2.50	6.30	10.00
France	0.98	1.10	1.80
Germany	0.41	1.90	5.10
Greece	0.46	0.50	1.30
Ireland	1.40	6.10	7.10
Italy	0.46	0.90	1.70
Netherlands	1.22	9.10	18.20

Portugal	0.56	1.30	2.20
Spain	0.82	0.60	0.90
Sweden	3.77	5.40	9.00
United Kingdom	2.20	7.0	5.50

Source: European Union.

This recent interest in telework is a reflection of the convergence of several important communication, legislative, societal, transportation, and workplace trends. Essentially, advances in communication technology, the growing interest in cost-reduction and retention concerns of employers, and increasing concerns regarding traffic congestion and air pollution have spurred on interest in this burgeoning trend. The following illustrate existing realities and/or trends from various perspectives that influence further investigation into the potentiality of more telework.

Automobile use and environmental concerns

The shape and structure of cities, limits on public transportation availability, and the increasing suburbanization of employment often make car ownership an economic necessity. Americans drive 6.3 billion miles a day, compared to 2.4 billion in 1965 (Consumer Federation of America, 1996). Since 1969 the average number of persons in a household fell from 3.16 to 2.56 in 1990 but the number of cars per household increased from 1.16 to 1.77 over the same period while the popularity of work-linked carpooling declined from 20.4% of all work trips in 1970 to 13.4% in 1990 (Ferguson, 1997). Another study shows that between 1980 and 1990, the percentage of people driving to work alone rose from 64% to 73% (Russell, 1996).

The result was that congestion grew from seriously affecting 41% of US urban interstate highways in 1975 to 69% in 1993 (Langhoff, 1999). With this came heightened concerns over environmental hazards and costs associated with increased levels of emissions generated by automobiles. In 1996, transportation accounted for 32% of US carbon dioxide emissions. In 1985, about 390 million metric tons of carbon were emitted by transportation sources; by 1996, nearly 450 million metric tons were emitted (US Federal Highway Administration, 1998).

Business concerns

US corporations' sense of space is expanding on a variety of levels: geographic (global markets), physical (virtual offices), and electronic (use of information and telecommunication technology) (Saveri, 1995). In order to develop and retain competitive advantages and/or to increase global competitiveness, the organizational structures of many firms have flattened. Firms have downsized and decentralized their operations in order to reduce costs and overheads, yet at the same time, these actions help to increase market flexibility and responsiveness.

In addition, the nature of work in the information era and the type of workers required for such work is changing. Work in this era is increasingly less labor intensive and more capital and knowledge intensive. Increased literacy and numeracy skills – not brawn – are required of today's employees. Knowledge based work is facilitated by computerization and automation, and thereby decreases the connection of work to physical spaces. Also, current tight labor markets – particularly within high-technology industries – make it increasingly difficult for employers to find and retain employees with needed skills and talents.

ITS concerns

ITS and telematic technologies undoubtedly have considerable potential to address the nation's increasing traffic congestion and safety concerns. Some ITS applications like anti-lock braking systems (ABS) have already proven to be effective and are popular features among auto users. Road telematic features, like the OnStar travel information service, are also popular and this type of technology is gaining significantly in its use. However, advanced technologies like voice and speech recognition, forward-looking radar and intelligent cruise control remain costly, emergent technologies that have really yet to take off. Related telematics applications suffer from similar challenges of reliability and upgradeability of features, meeting customer demands for simple, safe, real-time services, and overcoming lingering technical and cost problems (Eisenstein, 1999).

In term of infrastructure, telecommunications, in conjunction with institutional reforms, has played an increasing role in facilitating coordinated responses to incidents and in coordination of traffic management more generally. The challenges here are often far more to do with overcoming institutional constraints than in finding an appropriate technology to adopt. In many cases, public sector infrastructure authorities are lagging private sector on-vehicle systems in application.

Individual family trends

Demographic trends influence the labor market. For example, the 'Baby Bust' cohort (about 45 million persons) in the US is smaller than its predecessor, the 'Baby Boom' cohort (about 77

million persons), therefore fewer young persons are entering the workforce (Gross, 1996). New entrants to the workforce will increasingly comprise more technologically skilled persons who view jobs as temporary (Shulman and Reiser, 1996). Many baby boomers in the current labor market are a part of the sandwich generation – persons that must care for both young children and their aging parents. For example, 47% of US workers are required to provide either child or eldercare; and 66% of parents feel they do not have enough time to spend with their children.

Workers therefore, are seeking more flexible work options to address family obligations. Currently, upwards of 75% of employers now have part-time employment options, about 60% offer flextime options, and 45% offer job-sharing options (Williams, 1996). Thus, telework is viewed as an additional alternative work option that employers can offer employees.

Legislation

Several pieces of important legislation in the US have facilitated the overall interest in telework. They include the Americans with Disabilities Act that requires employers not to discriminate against persons with disabilities and that proper workplace accommodations be made for disabled persons. The 1990 Clean Air Act requires that employer trip reduction and vehicle occupancy programs be implemented for State Implementation programs. The 1991 Intermodal Surface Transportation Efficiency Act provides federal funds to develop telework programs. The 1998 Transportation Equity Act for the 21st Century/TEA Restoration Act, ‘builds and authorizes funds for highway improvement, safety, and research programs’ (US Department of Transportation. 1998).

Within the federal government, efforts have been made to promote a ‘family friendly’ work environment. According to the President, family-friendly environments were to be obtained through ‘broad use of flexible work arrangements to enable federal employees to better balance their work and family responsibilities ... increase employee effectiveness and job satisfaction while decreasing turnover rates and absenteeism’ (Weekly Compilation of Presidential Documents, 1994). Telework options are generally included in such flexible work options. In addition, in 1996, the President’s Management Council on Interagency Telecommuting Working Group desired that ‘each agency and department make telecommuting part of its overall strategy to improve government services to the American people’ (President's Management Council, 1996).

Finally, the National Telecommuting and Air Quality Act of 1999 requires the Secretary of Transportation to make a grant to a nonprofit private entity for the purpose of developing a pilot program for the use of telecommuting as a means of reducing air pollutants. In addition, under Public Law 106-246, the Administrator of the Environmental Protection Agency was required to make a grant for the first year of a 2-year program to implement telecommuting projects in five metropolitan areas. There have been other legislative initiatives; these are intended just to offer a flavor of what has happened.

Technological factors

Technological advances have made it easier and cheaper to communicate across geographic space. The advances have taken place with respect to a broad range of technologies and services

including: computer and communications manufacturing, electronic components, peripheral equipment and software, electronic signalization, and communication services (cellular, specialized mobile radio services, personal communication services, cordless, paging, and the like).

In addition the shift from analog to digital infrastructures and decreased dependence on networks, allows for significant increases in capacity (Seth and Sisodia, 1997). Both of these advances provide greater economies of scale, increase the features and services available, and reduce unit costs. The increasing number of technological options and the reduction in costs (as well as the number of persons with Internet access and the widespread availability of fax machines) make telecommuting options more viable – nationally and internationally. For example, in 1930 a 3-minute call from London to New York cost \$250 in 1990 dollars; by 2005 the same call may cost \$0.10 (Smith, 1996).

WHAT IS KNOWN ABOUT TELEWORK

The definition of telework adopted has significant implications for determining the actual number of teleworkers, and consequently for assessing the potential impact of teleworking on travel and related behavior. So far we have been very loose in our definitions to allow the conveyance of some general points, but precise definitions are important for quantification and for detecting changing trends over time.

According to the International Telework Association and Council, for example, there were some 19.6 million persons telecommuting in the US at least occasionally in 1999. Another source contended, however, that the number of telecommuters was more in the range of 21 million people – 5% of the workforce (Ruhling, 2000). The estimates of people who telework full-time are even more varied. One estimate asserts that 7.4 million people were full-time telecommuters in the late 1990s (Deeprise, 1999); yet, according to another, there were only 1 million telecommuters (Au, 2000). The only consistent fact seems to be that people prefer to telecommute on a part-time basis – generally one or two days per week (Mokhtarian and Bagley, 2000).

The variation in the figures illustrates that the accuracy of estimates and projections can be contingent upon how telework is defined. Korte and Wynne (1996), for example, explicitly note that, in Europe part of the difficulty in estimating telework figures is that there is a lack of reliable empirical data that makes both local and international comparisons difficult.

Often the definition of telework varies between studies. Distinctions are also often not made between self-employed home workers, contractor home workers, remote workers (i.e., salesmen) and telecommuters. Pratt (2000) contends, ‘Because the word telecommuting lacks a generally agreed-upon definition, when it is used in surveys it conveys various images to respondents. Thus, the data collected may be ambiguous and lead to errors of interpretation.’ In addition, attempting to rely on employer based data to generate estimates of the number of teleworkers proves problematic because ‘Employers themselves are probably not aware of the full extent of

telecommuting by their employees, as much of it takes place informally and occasionally' (Handy and Mokhtarian, 1995).

Given such concerns, Handy and Mokhtarian (1996) have argued that to develop sound estimates and produce solid forecasts for teleworking, emphasis must be placed on determining both the penetration and level of telecommuting. Penetration refers to the percentage of workers that telecommute; levels of telecommuting are based on telework occasions (frequency) and refer to the percentage of workers that telework on a given day. Not all surveys attempt to capture these two distinct sets of information. To establish a more consistent definition of telework, Korte and Wynne (1996) outline three required dimensions of telework:

- *Workplace location.* Criteria where work or part of it is to be completed:
 - Partial independence of workplace location from company,
 - Location is temporarily or permanently close to or at the place of residence,
 - Location remote from the company;
- *IT use.* Levels of communication between teleworkers and employers:
 - Low: telephone, stand alone computer equipment, delivery of work/tasks by mail,
 - High: telephone, fax machine, e-mail, PC or terminal linked to servers or mainframes, delivery of work/tasks transmitted via telecommunication network;
- *Organizational forms.* Nature/extent of organization for companies and employees vary:
 - Company – relocate functions, outsource, individual or micro-companies are free to locate elsewhere (home, shared office space, etc.);

- Teleworkers – home-based work, alternate work between home and office, mobile work (work anywhere) and telework centers.

Because of data limitations, and the rather slippery nature of the teleworking concept, information on its up-take and importance in the economy is, therefore, as we have seen, inevitably, poor. Telework is also but one manifestation of increasing technological advances, the degree of up-take of these advances, the use made of them, and the resulting human behavior. Salomon (2000) illustrates the interaction of these components at the individual and institutional levels. Table 4.3 illustrates the increasing complexity society faces with respect to work, service, and social options.

An interrelated component of this complexity is transportation, which is increasingly being influenced by information and telecommunication advances. At this juncture, however, the emphasis is simply on telework and its capacity to make significant impacts on modifying or reducing congestion and pollution. The potential benefits for employers and employees that may be realized from increasing the amounts of telework are summarized in Table 4.4.

Table 1.3 Types of technology advances and their areas of impact

Demand side:	Individuals/households	Institutions
Supply side:	<i>Social</i> Telephone, Internet, E-mail	<i>Labor</i> Telecommuting
Individuals/households	<i>Products/Services</i> Teleshopping, Teleservices, Tele-education, Telemedicine	<i>Products/Services</i> E-commerce, Teleconferencing, E-mail, EDI (Electronic Data Interchange)

Generally, traffic and environmental interests in telework have come from its potential effects on accessibility. (Salomon and Mokhtarian, 1998). Telework is conceptualized in many of these works as substituting trips to work while still providing the access (via telecommunication devices) needed to perform work functions. The reduction in the numbers of cars on the road, in turn, facilitates traffic management. Concomitantly, from the environmental standpoint, telework reduces vehicle-miles traveled (VMT) and the accompanying auto emissions. The Clean Air Act Corporation estimates that the average vehicle emits 1 gram of volatile organic compounds; 2 grams of nitrous oxides; and 5 grams of carbon monoxide per mile. Thus, fewer cars on the road generally translate into lower levels of air pollution.

Table 1.4 The nature of the potential costs and benefits of telework

Employer Benefits	Disbenefits	Employee Benefits	Disbenefits
Reduced car parking requirements lowers overheads	Requires employee self-discipline	Greater flexibility in work hours	
Reductions in office space requirements – lighting, space, furniture	Lower productivity (e.g., home based distractions, lack of direct supervision)	Greater flexibility in life-style	Requires self-discipline
Higher staff productivity through fewer interruptions	Less effective communication between personnel due to lack of proximity and/or interaction	Higher productivity through fewer interruptions	Lower productivity due to e.g., home based distractions, lack of supervision
Higher efficiency (e.g., less ‘paid’ time traveling)	Less opportunity for cross-fertilization resulting from social/professional face-to-face interactions	Lower car use and less fuel consumed therefore money saved	Reduced social/professional contact and lack of stimulation from face-to-face interactions
Less dependent on climate conditions (e.g., snow	Provision and maintenance of equipment		

days)			
Greater flexibility in work hours	Not all jobs lend themselves to telecommuting causing resentment amongst some staff	Achieve more life goals in a day	Requires dedicated space in the home
Facilitate outsourcing	Increased security problems	Ability to avoid traveling at congested times	Internal household conflicts

A review of various US telecommuting studies reveals that on commute days teleworkers drove about 51.8 miles in the latter part of the twentieth century; on telework days, teleworkers drive only 18.6 miles (National Environmental Policy Institute, 2000). In general, this work concluded regarding telework sessions.

- Average vehicle trips are reduced by 1.1 trips
- Average vehicle miles are reduced by 33–35 miles
- Teleworkers often generate non-commute trips, but total VMT are still lower than on non-telework days
- Teleworkers often generate business-related trips, but total VMT are still lower than on non-telework days.

In terms of the business sector, the implications for the company play a key role in the penetration of telework (American Management Association, 1999). Businesses normally need commercial or legal incentives, rather than perceptions of environmental concerns, in order to support telework; confronting social concerns seldom has a major positive impact on a firm's bottom line. Compliance with legal mandates, like the 1990 US Federal Clean Air Act, or the Americans with Disabilities Act, is one incentive, as providing telework options helps firms remain in compliance (Piskurich, 1996). There are, however, other reasons that firms establish telework programs including cost reductions (office space, turnover, and relocation); improved productivity and employee morale; and to access new labor markets.

There have also been other studies that have sought to evaluate and allocate the implications of teleworking in economic rather than physical terms. According to the International Telework Association and Council, for example, in the late 1990s, the cost and benefits associated with telecommuting in the US include.⁹

- \$2,086 in reduced absenteeism costs per teleworking employee per year (63% savings)
- \$685 in productivity gains annually per teleworker (22% increase)
- Retention savings of \$7,920 annually for each teleworker retained (avoids replacement cost).

⁹ An additional rule of thumb is that companies average savings of \$2 for every \$1 spent on telework programs (American Management Association, 1999).

While the uptake of telework is contingent upon organizations offering the option to their workers, the success of telework efforts more critically rests with a voluntary desire of employees to engage in telework, or at least having the opportunity to participate in a new work package of which teleworking is one component. In this context, Mokhtarian and Salomon (1994) sought to identify drivers, constraints and facilitators of telework for individuals. Drivers are factors that provide the incentive, motive, or reason for telecommuting and are seen to include:

- *Work-related factors*: aspects of the work environment that are uncomfortable or undesirable for the individual and/or the desire to work independently.
- *Family-related factors*: role responsibilities and/or the desire for more family time.
- *Leisure-related factors*: pursue interests, education, personal improvement,
- *Ideological factors*: promote environmentalism.
- *Transportation factors*: avoid commute; temporarily disabled, etc.

Constraints and facilitators are factors that either encourage or discourage telework and embrace:

- *Awareness of the option*: lack of awareness, misunderstanding;
- *Organizational related*: lack of employer support, managerial disapproval;
- *Job related*: job suitability; availability of technology resources; high costs; and

- *Personality characteristics*: risk averse, social needs, level of discipline; benefit of commute; and conducive household environment.

The individual's decision process to telecommute is complex, however; telecommuters weigh the drivers of, and constraints to, their actions and generally, according to this work, favor telework options 1 to 3 days per week for several reasons including: travel difficulties are avoided; improved concentration and fewer interruptions; increased autonomy; and lower work-related costs (Telework Analytics International, Inc., 1999).

CONCERNS AROUND TELEWORK

While traffic planners have for many years been exploring the role of teleworking as a means of reducing pressure on congested transport facilities, others, and particularly social scientists, have been more interested in some of the wider problems associated with more teleworking. The concerns are wide-ranging, and some of the key points have been addressed elsewhere which influences their depth here, but they include the following factors.

Confidence and trust

The nature of telework can influence the nature of work leading, for example, to increased use of flexible work hours, satellite offices and alternative office arrangements like hoteling, which involves reducing the number of private offices and having employees share or reserve office

space only when a workspace in the primary office is needed (Saveri, 1995). The influence of telework also involves aspects of social connectedness/cohesion and trust.

It has been suggested by Fukuyama (1996) that social interactions at workplaces are an important element of fostering a sense of community over individualism, arguing that, 'Work and money are much more important as sources of identity, status and dignity ... This kind of recognition cannot be achieved by individuals; it can come about only in a social context.' Teleworking can potentially interfere with this community building process. Telework can also create dimensions of uncertainty within an organization and thereby reduce trust among managers and staff.¹⁰

Much, however, would seem to depend on the technology adopted. If the costs of videoconferencing equipment and such fall then there is more potential for the virtual inclusion of remote workers within a pseudo office environment. By keeping teleworkers socially connected new forms of organizational communication may emerge, helping to foster and retain traditional levels of trust.

Telecommuting choice

The context in which teleworking is used within an organization's overall structure can influence its successful up-take. Mitchell (1996) helpfully outlines several micro and macro parameters

¹⁰ Trust is important in the workplace according to management scientists because it 'reduces social complexity by going beyond available information and generalizing expectations of behaviors in that it replaces missing information with an internally guaranteed certainty' (Blois, 1999).

that help guide telework discussions and the formulation of telework programs and policies.

Micro-level parameters are those that pertain to individuals or a particular firm and include:

- *Person* – skills, attitudes, preferences, etc.
- *Employment context* – single employer, self-employment, virtual firm, etc.
- *Task set* – nature of the work to be completed (concentrative versus. communicative).
- *Nature of external relationships* – customer preference for face-to-face interaction, etc.
- *Locational context* – home-based, telecenters, mobile, etc.
- *Nature of internal work* – level of interaction/interdependency with others, work styles, etc.
- *Technology context* – level of existing technology use, comfort with technology use, costs associated with technology resources/equipment.

More macro-level parameters are strategic factors for firms or regions to assess when considering telework policies. They may include:

- *Geographical context* – regional characteristics.
- *Sectoral context* – impact on different industries; industry bias; strengths of industries, etc.
- *Product and delivery characteristics* – understanding of attention needed for product/delivery mix; global market issues.

- *Skills context* – consideration of types of skills needed/need to be developed.
- *Regulatory context* – regulations are favorable/unfavorable to telework.
- *Policy context* – the policy focus is to encourage innovation; protect workers, etc.

Taking the time to thoroughly consider these factors reduces the likelihood of a company developing ill-conceived or constructed programs or policies. At the same time, examining these micro and macro factors to potential telework, but also non-teleworking employees, helps those involved better understand the multifaceted nature of telework.

Bernardino and Ben-Akiva's (1996) decision model for the adoption of telework incorporates concerns and perspectives of both the employer and the employee. The motivations and constraints of these parties differ, yet are contingent upon one another. For example, in designing a telework program, firms will consider profitability, teleworking frequency, organizational needs and the like. The types of programs offered to employees will cause workers to evaluate the qualities and characteristics of the offering, their own motivations and concerns, etc., before making a decision to adopt telework as an option. Given that employees are central to the success of telework, it is important to understand and carefully assess factors that influence their decisions to undertake telework.

Mokhtarian and Salomon (1994) contend that the individual decision-making process associated with telecommuting is complex. Social and psychological variables are, however, likely given short shrift by transportation planners when the advantages of telecommuting are considered. Mokhtarian and Salomon note, 'the choice to telecommute is not a classic residential

or work-location decision, as the choice is usually to telecommute only part time [1–2 days/week], and again can be motivated by different factors than are included in traditional location models’.

In another study, Mokhtarian and Salomon (1996a) found that about 12% of their sample did not want to commute; a finding that correlates with the 15% of hard core telecommuters and 15% who did not even think about telecommuting found by of Mahmassani et al. (1993) – see Table 4.5. The table also suggests that most employees only favor teleworking under certain conditions. The majority of respondents are only willing to accept telework options provided the employers pay all related costs and only about 35% would be willing to work from home every day provided that they received a pay increase as well as the employer paying all related costs.

In their work, Mokhtarian and Salomon (1996a) also found that telecommuting was an option for only 11% of their sample, and that 68% had at least one constraint on their choice; job unsuitability, manager disapproval, and lack of awareness. They also (Mokhtarian and Salomon, 1996b) found that only two characteristics significantly differ between those teleworking and non-teleworkers: presence of children under age 6 and occupation. Managers are more likely to telecommute, as are those with children under 6 years of age. These findings provide insight into the constraints on the potential size of the labor force amenable to telework and their characteristics.

Table 1.5 Stated preferences for telecommuting program (percentage of responses)

Program scenario	1	2	3	4
Salary same, employer pays all costs	21.6	44.5	22.0	11.8
Salary same, employee pays for new phone number	11.9	25.8	33.4	28.9
Salary same, employee buys PC	9.2	16.0	31.8	43.0
Salary increases 5%, employer pays all costs	34.0	52.1	NA	13.8
Salary increases 5%, employee pays part of costs	16.2	28.2	21.2	58.1
Salary decreases 5%, employer pays all costs	7.9	12.8	21.2	58.1
Salary decreases 10% employer pays all costs	5.2	5.0	12.4	77.4

Key: 1 = Work from home everyday; 2 = Work from home several days/week; 3 = Possibly work from home; and 4 = Do not want to work from home.

Source: Mahmassani *et al.* (1993).

Travel and personal environmental factors

Following the seminal work of Zahavi, and based on global figures, Schafer and Victor (2000) find that on average people spend about 1.1 hours per day traveling. The implication is that in general people have a base level need for mobility. In addition, some people derive a degree of utility from discretionary travel – leisure and miscellaneous travel. Consequently, some people remain undaunted by telework options aimed at reducing their travel, leading Salomon and Mokhtarian (1998) to argue that it is important to ascertain the number of individuals that will travel for unobserved objective and subjective reasons. For example, some people may enjoy the

buffer time that commuting affords to transition in and out of home and work roles (Richter, 1990).

A love of cars is also culturally embedded in many societies; inherent in car ownership are status and a sense of freedom and independence (Jensen, 1999).¹¹ This reality needs to be incorporated into attempts to implement telework initiatives, and when making projections about the potential impacts of teleworking.

Jou and Mahmassani (1997) analyzed trip-chaining behavior associated with work trips and found that the phenomenon is more extensive during the evening commute. Numerous non-work activities are performed during the work commute, which diminishes the attractiveness of public transit options; longer commutes afford more trip stops; women make more stops during their morning work commutes; persons over age 45 are less inclined to make stops; persons in lower-wage jobs make fewer trip stops; and workers that like to arrive to work early are more inclined to make trip stops during the work commute. Many of these trip stops are not work-related and would likely involve travel irrespective of the option to telecommute.

In another study, Sun et al. (1998) find that home owners or those buying homes generate 40% more daily trips and 84% more VMT than renters and that living in a single family home versus an apartment or condominium produces 120% more VMT with possession of a car phone generating 52% more VMT and 22.9% more trips. Persons in high-density areas travel 19%

¹¹ An indication of the attachment to the car is given in Baldassare et al. (1998). In a survey of suburban attitudes on efforts to reduce traffic congestion, only about 20% of solo drivers would be willing to stop driving alone if charged parking fees, smog fees, or congestion fees, and a third said they would not change their current driving patterns if carpools, vanpools or public transit were expanded in their areas. Forty-two percent would not change their existing driving habits if paid a cash bonus by their employer to use carpools and the like.

fewer VMT than those in low-density areas, and households with low access to their jobs made 17.3 trips and 72.3 VMT, compared with those with high access to employment (15.2 trips and 44.5 VMT). This suggests that a range of location factors influence travel behavior and that telework options may often be dominated by some of these.

There are also issues about retention rates once people have experienced a period of teleworking. Some studies suggest that about half of those teleworking stop after 9 to 18 months (Nilles and Mokhtarian, 1998). The desire to telework seems to be contingent upon life-cycle factors and work/career conditions. Changes in either of these may reduce the desire to telecommute even after initiation. Also, people may tire of working from home given the relative social isolation it can involve.

Business concerns

A range of factors affect the attitudes of employers towards teleworking. Often it depends on where they are in the value chain – some types of business are simply not amenable to large-scale teleworking (see again Figure 2.2) – but there are a variety of other factors that can come into play. The interest here is with companies that have scope for at least part of their activities being conducted away from their premises. Reasons found for not doing so include (Pratt, 1997):

- *Security/privacy costs.* Handheld and loaned computers used at remote work cannot be monitored, unlike traditional desktop machines, which increase the threat of viruses, and the

potential for unauthorized intrusion, and theft, damage or destruction of information assets and trade secrets.

- *Hidden costs.* Employer liability and property insurance costs exist with formal telework programs; workers' compensation costs can apply to teleworkers; and there may be legal over-time stipulations.
- *Fairness issues.* Generally only certain jobs are suitable for telework; creating positive effects with those that volunteer and are allowed to telework, but resentment by non-teleworkers. Anti-discrimination laws may also play a role.
- *Training costs.* Training is often required for managers and employees to adapt to new procedures and policies, management styles, alternative workplaces, and responsibilities; non-telework employee training and the like are also often associated with formal telework programs.
- *Disruption of team-based efforts.* With telework, higher levels of coordination are required among management and staff that may involve increased equipment and training costs.
- *Limited effectiveness of benchmarking.* Due to corporate culture concerns, it is more difficult for firms to adapt the telework programs of others, leading to unanticipated costs associated with establishing formal programs and use of different telework models.
- *Corporate culture.* In a recent study, 35% of respondents claimed that a resistant corporate culture was the primary barrier in failing to implement telecommuting programs.

Individual concerns

In most countries telecommuting is voluntary and its up-take based upon individual attributes (gender, income, access to equipment, etc.), job characteristics, disposition toward telework, transportation preferences, and the price elasticity of demand associated with telecommuting (Yen, 2000). Because of the range of factors involved, it is often difficult for companies to assess the viability of teleworking or the type of telework structure that would appeal to their employees. The type of repetitive work that may be seen as technically the easiest to monitor from an employees perspective, may also be the type where employees may prefer more human contact about them.

Individuals tend to prefer home-based telework to center-based options, but this may lead to conflicts between personal and business interests in relation to the type of telework adopted. Businesses, for professional reasons, and because of their customer preferences, may prefer center-based options to maximize control of employees (Bagely and Mokhtarian, 1997). Where there is commercial confidentiality involved or security, this may prove a significant handicap to home-working.

Gender/ethnicity considerations

As seen in Chapter 2, gender can in some cases affect travel behavior. McGuckin and Murakami (1999) find in their analysis of trip chaining that women are more inclined than men to make stops at multiple locations during the commute, and also make more trips to and from work. Single men and women with no children have similar commute patterns while in households with children, women have complex trip chains – more so than women without children or men.

Single mothers of small children trip chain more than single fathers or dual parent households. Further, investigation by Turner and Niemeier (1997) give support for the household responsibility hypothesis that suggests that the idea that women have greater household burdens and hence choose shorter journey-to-work commutes.

Mauch and Taylor (1997) find that racial and ethnic variations in US travel patterns among men and women are explained by income, status, employment, and auto availability, with gender having a more direct effect on travel. Women make more child-related and household-related trips than men. The gender difference in travel times is 4.5 minutes for whites, and 1.8 minutes for Hispanics. Gender differences for average travel times do not vary much by race or ethnicity; and gender differences in child-related trips during the work trip are 60% for blacks, 152% for whites, and 212% for Hispanics.

This all supports the fact that future telework uptake in the US may have gender and racial biases as well as occupation and location biases. This in turn will affect the types of substitution and complementarity effects that will develop with transportation with more specific implications for traffic patterns.

TELEWORK POTENTIAL

Overall potential for teleworking

Much effort has gone into looking at exactly how much work travel could be diverted to teleworking. Some of the numbers are clearly spurious, and are often thrown up as part of advocacy campaigns.¹² Nevertheless they do offer some general thoughts on exactly how much work, and with it work travel, could theoretically be affected by teleworking.

The most common breakdown is by function and the separation of those that are more immediately amenable to teleworking. The value chain concept of Porter (1980) offers some general insights into this and, for example, was used by Eldid and Minoli (1995). For example, there is more opportunity for stages involving upper management, human resource management, technology development, procurement, marketing, and sales than there is in inbound and outbound logistics, and operations.

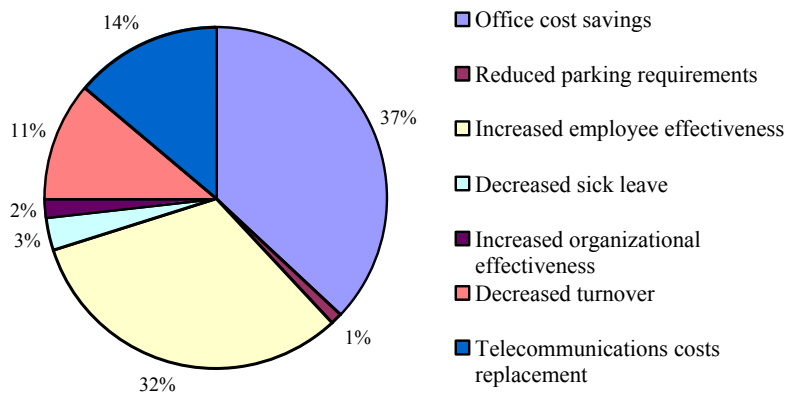
But the immediate up-take of telecommuting by companies will depend not only on potential, but also on the relative savings that can now be attained. This revolves around the particular features of each stage in the value chain. Nilles (1997) offers some general observations on the potential savings that come from teleworking (Figure 4.3). These need to be tied to the type of activities a company or division of a large company is engaged in, and its internal structure.¹³ Such calculations are difficult, especially for outsiders who are not privy to a company's full operational picture.

Potential for teleworking in the US National Capital Region

¹² Ilan Salomon once reported at a seminar in Europe that he had sought to verify the basis of a published forecast that telecommuting would constitute 12% to 13% of trips. He could not find any evidence in the supporting references that provided any basis for this figure.

¹³ This is a topic returned to in a somewhat different context in Chapter 6.

Labor markets are extremely heterogeneous, not only in terms of the types of industry or production involved but also according to location. There are wide geographical variations in the ways they function and, *ipso facto*, in their potential for widespread adoption of teleworking. Nevertheless, while generalizations are difficult, case study material can prove insightful provided the specifics context of the case study is not forgotten.



Source: Nilles (1997).

Figure 1.2 Potential savings to employers from teleworking

The National Capital Region¹⁴ is one that suffers from severe traffic congestion and pollution problems. The region ranks among the worst five areas in the US for congestion (Table 4.6).

¹⁴ The National Capital Region embraces Northern Virginia, Southern Maryland and the District of Columbia. It is characterized by a predominance of service industries and government employment.

Teleworking has been advocated as a policy option, particularly in Northern Virginia, because of the nature of local employment, particularly executive, administration, managerial; professional specialty; technicians and related; sales; and administrative support. In Virginia some 65% of employment is in these occupations. In addition, Northern Virginia has a large concentration of high technology companies engaged in telecommunications, Internet industries, and information technology that employ people familiar with the technology of teleworking (Behr, 1998).

In April 2000, the Metropolitan Washington Conference of Governments (MWCOG) (2000) announced a regional telecommuting goal to increase the percentage of telecommuters to 20% of the workforce by 2005. It was argued that if this were achieved there would be 70,000 fewer cars on the road each day. According to the MWCOG, in 1996, 7% of workers were telecommuting in the region; in 1998 this had grown to 12%. It was argued that achieving a 20% telecommuting goal was reasonable given the growth in telework in the region.

Table 1.6 The most congested US urban areas

1. Los Angeles	7. Atlanta
2. Seattle	8. Boston
3. San Francisco-Oakland	9. Detroit
4. Washington	10. San Diego
5. Chicago	11. Las Vegas
6. Miami	

MWCOG sponsored a telework project involving 270 teleworkers from August 1997 to June 1998. It found that 70% were between ages 35–54, with 61% of being female, and with 60%

having incomes over \$55,000 in 1996. The average one-way commute distance was 25 miles and average commute time was 44 minutes to work and 48 minutes home. Forty percent of participants in the project teleworked one or two days per week and 24% reported that their schedules varied from week to week. Eighty percent worked from home (as opposed to a telecenter) and saved an estimated 97 minutes of commute time on telework days.

Looking at the picture more broadly, however, the MCWOG data show less than 1% of those surveyed participated in telecommuting at least one day per week and that about 50% lived in the Virginia part of the region with lone driving the primary commute mode irrespective of gender or race. Of those who drove alone, the primary alternative commute modes used during the previous year were transit (57.7%) and carpooling (32%). Half of those who changed their commute mode did so because of changes in employment or work hours and to save money.

The region's largest single employer, the US federal government, is a strong promoter of telecommuting options and efforts have been made to promote a 'family friendly' work environment.¹⁵ Telework options are generally included in such flexible work options. In addition, in 1996, the President's Management Council on Interagency Telecommuting Working Group desired that 'each agency and department make telecommuting part of its overall strategy to improve government services to the American people.'

Given the strong federal presence in the region, the Washington metropolitan area benefits from federal resources to support efforts like telework and to conduct small-scale projects. For

¹⁵ According to the US President, family-friendly environments were to be obtained through 'broad use of flexible work arrangements to enable federal employees to better balance their work and family responsibilities ... increase employee effectiveness and job satisfaction while decreasing turnover rates and absenteeism' (Weekly Compilation of Presidential Documents. July 18, 1994).

example, as part of the National Telecommuting and Air Quality Act of 1999, the Washington area will be involved in the Telework Emissions Trading Pilot Program (National Environmental Policy Institute, 2000), whereby test cities received \$250,000 to implement an emissions trading program to give incentives for businesses to implement telework programs.

Lowe (1998) examined commuting patterns in the Washington metropolitan area using 1980 data and found that commuting dispersion and complexity increases significantly beyond about 12 miles from the geographic center of agglomeration. These are influenced by the interrelationships between the pattern of residential densities and the various overall patterns of employment concentrations. This suggests that commuting patterns will continue to evolve in this fashion in the metro area as the suburbanization of employment continues. Telework options may contribute to the pattern of intra-county commuting or further disperse commuting patterns as persons move further in to rural areas as the need to commute to work declines.

CONCLUSIONS

Telework holds promise as a potential mechanism to reduce traffic congestion and air pollution.¹⁶ This alternative, however, is no panacea. There are ample disbenefits and barriers to implementing telework. In addition to promoting the option to businesses, individual employees

¹⁶ In many ways the enhanced potential that modern communications holds for at least working partly at home is largely in terms of giving wider flexibility to overall life-style. It allows for greater interactions within family units and a much larger choice set in terms of how individuals and households divide up their time.

must possess the motivation to voluntarily telecommute. There are numerous social, psychological, and often, economic factors that must be brought to bear before opting to telework. In addition, the interests of businesses and individuals do not always coincide on matters such as telework sites. Employees largely prefer home-based options. Due to the nascent emergence of telework and/or for management/professional reasons, businesses may prefer employees to telecommute from a workcenter under formal telework programs.

Society's love for cars and leisure driving are cultural factors that come to bear. Research indicates that discretionary driving is a very real phenomenon and is a form of utility that is not easily surrendered (Salomon and Mokhtarian, 1998). There is a core of persons unwilling to accept telework options. Others simply need the commute time to 'unwind' or redirect their focus between other activities, or they simply enjoy driving. Although work trips may be shortened, or eliminated, by telecommuting, travel and trip making continues. Trip generation and distance is partially determined by gender, household responsibility, presence of children and income. These are factors that are largely unalterable.

Finally, suburbanization of employment and residences contributes to the shape of the modern urban form. Telework options may promote continued dispersion and complex travel patterns as persons move further into remote areas or it may not. It is too early to predict. In addition to wider options that telecommunications is offering, there are a multitude of other changes that are taking place that are influencing land-use patterns and urban form. Society is multidimensional and so are the forces that shape it.

VIDEOCONFERENCING AND WORK TRAVEL

One critically important technology for promoting telework is videoconferencing. There are a number of different ways of videoconferencing but they all involve the same broad principles. Technically, videoconferencing entails electronic communication by both images and sound between participating individuals. It differs from rather older, established methods of electronic conferencing, such as teleconferencing, that only links up participants by sound through telephone connections. This means that there it offers major advantages over these older systems terms of the degree of information sent and received.

Each participating group at a videoconference both sees and hears others involved. In physical terms it entails sitting in front of a television like receiver which both provides input from other participants (their images and voices) and, through microphones and cameras, sends information to them. When there are a number of individuals involved at any one location in the conference, specialized studios can be employed involving rather more sophisticated equipment that permits groups of people to participate together. In other cases, where there may just be one individual at each location there are facilities that allow appropriate computers to be used in the office with no special spatial requirements.

The images of participants are often complemented by various other technologies that allow printed material and other physical objects to be seen at the same time, and can also involve concurrent interactions with the World-wide Web and the like.

The gradual universal up-take of tele-education, and videoconferencing involving visual links has, in many respects been rather sluggish compared to early expectations; teleconferencing being taken-up more rapidly. This is despite the fact that numerous studies have, for instance, shown that, in practice, people conducting meetings electronically from their places of work could avoid many work trips. An oft-cited figure is that of the European Conference of Ministers of Transport (1983) that technically 13% to 23% of trips could be substituted by telecommunications and, while many of these may be commuter trips, a proportion involves in-work activities.

Things are, however, gradually changing and the focus here is on the more recent developments in videoconferencing and related technologies in terms of their interrelationship with trips made as part of employment.

THE DEVELOPMENT OF VIDEOCONFERENCING

The idea of videoconferencing and similar concepts is certainly not new – pioneering systems were demonstrated as early as the 1950s – but as with some other telecommunications media its adoption has been relatively slow. In 1956 AT&T built the first ‘Picturephone’ test system and introduced it at the 1964 World’s Fair in New York, marketing it in 1970 at \$160 (current price) per month. In 1971 Ericsson demonstrated the first transatlantic video telephone. By 1986 PictureTel was marketing a conferencing system costing \$80,000 (current price) with an hourly

line charge of \$100. By 1991 the company was marketing a black and white system for \$20,000 with a \$30 per hour line charge, and a year later AT&T brought out a \$1,500 videophone for \$1,500.

The next decade saw a rapid movement forward in technology as standards and protocols were established; products such as VocalTec Internet Phone, Microsoft NetMeeting, Virtual Room and Videoconferencing System came onto the market. By 2001 transatlantic surgery was being performed (a gallbladder operation) using a videoconference link, reporters in Afghanistan were using \$7,950 portable satellite videophones to broadcast live on the war, and commercial videophones were being sold for \$570. Now computers and telephones are regularly fitted with video facilities allowing personal meetings to be more interactive.

While videoconferences have been presented as a valuable alternative to certain types of business travel for quite some time, empirical evidence of the rising market share for this medium on business travel behavior has, however, until recently, been hard to find.

Explanations for the relatively slow take-off of the technology normally refer to the fact that for most purposes face-to-face contacts are still more efficient and cheaper in generalized cost terms. But there are other barriers. International use can, for example, be problematic across several times zones, and there may be technical problems and congestion associated with the line. There is also evidence that different nationalities have different preferences when it comes to forms of communication; a study of European academics, for instance, found that, although there emerged a general complementarity between the use of telecommunications and face-to-

face meetings, preferences for the various media for communications varied by country (Button et al., 1993).¹⁷

The world is, however, changing. Costs of videoconference equipment and associated line time have fallen considerably in recent years and are forecast to fall even more dramatically, the quality of image has improved and congestion on transport networks is pushing up the costs of face-to-face meetings.¹⁸ In a comparative study of the possible uptake of new telematic technologies as they might affect traffic congestion, videoconferencing was singled out to probably be of more short-term significance than most other developments (Button, 1991).

Further, the long-term importance of some forms of telecommunications as possible substitutes for transportation is, as we have seen, a topic of immediate relevance. There is mounting concern over the environmental damage done by transportation and many governments are admitting that fiscal expediency will prevent traditional means of funding infrastructure developments from being used to meet projected unrestrained traffic growth. While, as we have seen much, of this concern relates to peak period, urban commuter movements, it is not absent in the case of work-related travel. The mounting public concern over noise pollution at airports and the fear of the damage done by high-level con-trails is, for example, acting as a significant

¹⁷ Different priorities in communications can also be seen in the up-take of cellular telephones. In 2000, for example, 25% of the population of Italy had a cell phone, 13% of France's population, 13% of Germany's, 18% of the UK's, 48% of Sweden's, and 13% of Spain's.

¹⁸ The 'principal-agent' effect has also probably tended to favor personal travel. With the employee not bearing the costs of a business there is a tendency to seek options where there are external benefits (e.g., an extended stay or visit to a new place) and this can lead to a higher personal return for the worker in selecting a mode that allows personal travel. There is some evidence in terms of equipment sales that the down-turn in the global economy following the terrorist attacks on the US in 2001 stimulated increased use of videoconferencing as companies became more cost conscious and as businessmen became concerned about the safety implications of personal travel.

constraint on the longer-term expansion of air transportation; a major mode used by modern business travelers in a globalizing economy.

On the other hand, technology and continuing economic regulatory reforms, notably market liberalization and privatization, in many countries seem likely to both facilitate the continued improvements in the quality of telecommunications and further bring its real costs down significantly.¹⁹ Societal trends amongst the younger generation, brought up in an ‘electronic’ world, also mean that personal resistance to the use of videoconferencing and related technologies is far weaker than it was even in the in the recent past.

Although still at a relatively low level, but growing rapidly, world-wide use of videoconferencing would seem to be increasing. A survey of 100 US organizations regularly using videoconferencing in the early 1990s found that videoconferencing had doubled since an earlier 1985 survey (conducted by D.J. Bush Associates and reported in Lehman, 1991). At a global level it has been estimated that image communication is growing at about 25% to 39% per annum. Some 60% to 70% of it has traditionally been done in the US, with about 25% in Europe and much of the remainder in Japan (Douglas, 1989).

In absolute terms, however, use of the facility is limited. In 1988 the best estimates suggested that fewer than 6,000 units had been installed in the US. Equally, within Europe the up-take has been gradual. In part, high line costs and different standards offered by the national PTTs,

¹⁹ This must, though, be put into the context of reductions in the costs of some competing and complementary forms of transport. In the context of medium and long business travel, for example, the advent of low-cost airlines has reduced the costs of using that mode considerably.

coupled with user concern over the quality of service engendered by the crude technology associated with early systems, have hindered the development of the international system.

In this context, we explore some of the recent growth trends in videoconferencing and the future role of videoconferencing as a substitute or complement for face-to-face contacts. More specifically, the impact of videoconferencing on business travel demand is studied by looking at alternatives where the medium enjoys a comparative advantage over alternatives. This economic approach is in contrast to the extensive literature on the technical aspects of videoconferencing. Further, the literature on the socio-economic aspects of videoconferencing tends to focus in particular on the possibility of fostering its greater use as a means of limiting mounting problems of traffic congestion and traffic related environmental degradation (e.g., Bethany et al, 1991; Button, 1992; Sviden, 1983).

THE USES OF VIDEOCONFERENCING

Work interactions may take a variety of forms, some more suitable for videoconferencing, but also some easier to examine from an academic perspective. This has resulted in an emphasis on looking at certain types of interactions, but probably the most important being interactions that take place within the employment context. Figure 5.1 offers a simple breakdown of the main

typologies of communicative interactions in terms of whether they are essentially person or group driven.²⁰

FROM/TO	Individual	Group	
Individual	A	B	
Group	C	D	

Figure 2.1 Various workplace communications interfaces

- *Individual to group communications* (Category **B**) involves such things as research dissemination, education, and the passing down of instructions from higher levels of management. The information being moved normally has limited specific importance and any considerations of matters of confidentiality are minimal. Indeed, often the maximum spread of information is being aimed for. The exceptions to this can be at the higher levels of management where the group involved is clearly defined and information is restricted.
- *Individual to individual communications* (Category **A**) has traditionally been the domain of those interested in language, writing, psychology, education, and personal forms of communication. This has changed recently with economists, for example, being interested in issues of the importance of asymmetry in personal decision-making and in spatial analysis where

²⁰ This section draws upon Button and Maggi (1995).

there has been a view that aggregation of group actions provides a basis for macroeconomic analysis.

For the internal working of companies, it is important in terms of decision-making at various levels of management where personal contacts are important and communications down ‘ladders’ where, again, small numbers of individuals need to be informed. High degrees of confidentiality can be important. Telephone conversations tend to dominate electronic communications for this type of interaction, especially when the parties have enjoyed prior contact.

- *Group to individual communications (Category C)* often concerns feedback or planning actions. The aim is that key decision-makers have full, or at least necessary, information from others in the company or from suppliers or customers. Often this can be at a macro-level if higher management wishes to convey information to the larger work force. This fits more with analysis of markets and managerial practices and the flow of information is generally unidirectional, although interactions are not entirely missing.
- *Group to group communications (Category D)* are generally at the meson-level involving discussions and the interchange of information at various levels of a company. These often involve regular meetings or ‘brain-storming’ sessions aimed at tackling specific problems, presenting status reports, or developing futures. Videoconferencing is playing an increasing role in this type of interaction, especially where purpose built facilities offer a high level of sophistication in the techniques available for conveying information.

The role of videoconferencing and telecommunications in the workplace can also be looked at in another way (Figure 2.2). This is in terms of the time it takes to conduct interactions between people and the nature of the players/actors involved.

Communications with international, or long-distance time dimensions, tend to be more time consuming in many cases if there is to be face-to-face communications, although this issue is finessed a little later in the chapter. Equally, communications with clients is often time consuming because of a lack of full familiarity and the need for bargaining compared to intra-company communications between levels of management. The potential gains for substituting face-to-face communication thus vary according to the function of communications as well as to the scale of the parties involved.

THE DEMAND FOR VIDEOCONFERENCING

To understanding what is happening with respect to videoconferencing, and also to develop any sensible scenario concerning future developments, it is important to initially gain a better understanding of the market for videoconferencing services.²¹ The demand for videoconferencing services is almost always, like transportation services, derived from the end needs of an industrial or commercial company. It is not a final product. There is also a diverse

²¹ This may be a market external to the user, in the sense that the facility is hired from another company, or public agency, or it may be internal in the sense that the user makes use of his undertakings' equipment. The markets are, assuming companies have reliable internal accounting procedures, essentially the same in practice.

range of costs associated with electing for a videoconference compared to some other form of communication, including face-to-face meetings.

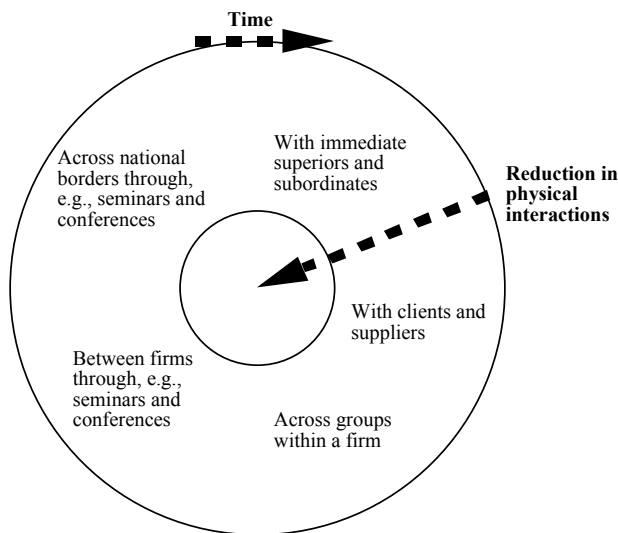


Figure 2.2 Work induced interactions

One way of looking at these factors is set out in Figure 2.3 that provides a schema setting out the types of cost decisions that have to be made when deciding to videoconference.

The immediate financial costs are the most obvious items, and the ones that frequently receive the most attention in studies of the subject. In the past the fact was that these costs were high, both because of equipment and studio costs and because of line costs. The opportunity time costs have received rather less attention although there is evidence that over some distances, the costs

of face-to-face meeting can be lower than for videoconferencing; this can, for example, happen when there are significant time-zone effects.²² Of key importance here are the number of participants involved, the number of locations concerned, the distance separating the parties and the length of the meetings.

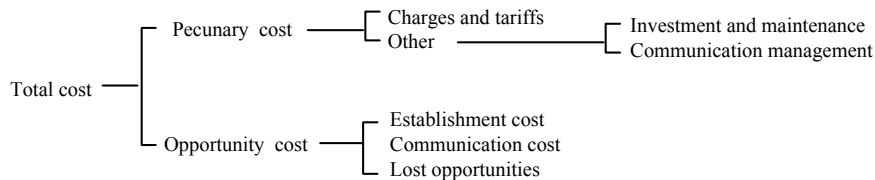


Figure 2.3 The costs of videoconferencing

To help separate the various issues involved in deciding whether to engage in videoconferencing activities it is useful to decompose the costs of videoconferencing versus face-to-face contacts into four main components (see Table 2.1). For simplification, we assume that both communications options are available, that our concern is with a company's long term decisions regarding its communications strategy and that the company is interested in minimizing the longer run average costs of its communications. The relevant costs making up the long run average costs (LACs) then become those in Table 2.1.

²² Some data on these relative costs in the UK during the 1990s are found in Button (1992b).

Table 2.1 Elements of the long-run average total costs of meetings by videoconference and through travel

	<i>Fixed Cost</i>	<i>Transmission Time</i>	<i>Distance</i>
<i>Travel</i>	0	0	$(\frac{M}{E_{travel}} VT + \frac{D}{V_{travel}} VT) D \cdot TD_{travel}$
<i>Video</i>	$\frac{I_{video} + CC_{video}}{Y}$	$\frac{M}{E_{video}} TC_{video}$	$(\frac{M}{E_{video}} VT + 0) D \cdot TD_{video}$
<i>Travel</i>	0	0	$(\frac{M}{E_{travel}} VT + \frac{D}{V_{travel}} VT) D \cdot TD_{travel}$

- *The average fixed costs of communication.* In terms of face-to-face contacts these are effectively zero. With videoconferencing there are the initial costs of establishing the communications infrastructure (studios and equipment), I, and of the communications concept (internal restructuring to handle the new media akin to that required with computerization of accounts), CC, and these are spread over the contacts, Y, made.
- *The average monetary cost of transmitting the message.* This embraces the time per contact, M/E, multiplied by the monetary cost of contact per time unit, TC. Since the monetary contact cost is generally zero for travel when the meeting is held on the premises of one of the participants, this item falls from consideration in the case of travel to meetings.

For videoconferencing, however, there are the fixed and time-dependent tariffs levied by the operator of the line and, possibly, studio rental costs. The actual time per contact depends upon both the function of the message itself, M (for example, how complex it is), and the efficiency of the medium in transmitting it, E .

- *The value of time.* Time has value to individuals and, in general, people prefer to spend the least time possible on any interaction.²³ We denote this value as VT . The full time cost of communication is composed of travel time, D/V (where V is speed) and transmission time, M/E . In the table travel time for videoconferencing is assumed to be zero although in some cases there may be a need to travel to a studio.
- *The monetary costs of distance.* This reflects differing costs of long as opposed to short distance communications and is closely correlated with the distance involved, D , times the distance-dependent tariff, TD .

Thinking of the comparative position of videoconferences in terms of the long-run average cost equations depicted in Table 2.1 raises a number of questions.

What are the implications of the differing cost curves? Much depends on the individual cost parameters, but in Figure 2.4 combinations of LAC curves for face-to-face contact and

²³ In transportation modeling one of the standard approaches to assessing the implications of any change to a transportation network involves estimating the demand elasticity of travel with respect to 'generalized cost', where this latter term reflects the combined money and time (converted into a monetary equivalence) of using the new facility versus the old.

videoconferencing with respect to the distance apart of the relevant parties are presented that illustrate some of the arguments.²⁴

If the slopes of both long-run cost curves are relatively shallow because the information being conveyed is relatively unsophisticated (case A), actual meetings with face-to-face contacts will be the cheaper mode and only if contacts are very frequent per time period will videoconferencing eventually have lower cost. Indeed, casual observation shows that for short distances contacts are frequently made face-to-face even for very banal communication issues.

For more complex communication over long distances (case B) marginal cost is important and, because of the expensive technology required to convey such information electronically, face-to-face contacts will certainly have lower cost than videoconferencing.²⁵ In this case, however, if communication had a very high utility, it might pay to invest in more sophisticated videoconferencing facilities, with a high fixed cost but lower variable time cost (as indicated by the thick line representing new videoconferencing technologies seen in case D). In case C marginal contact cost is lower for the telecommunication mode, for example for simple communications over long distances, videoconferencing will prove the lower cost medium except for when there are relatively few contacts.

²⁴ A rigorous derivation of this modeling framework is contained in Maggi (1993).

²⁵ This is especially so if there are time zone factors to be taken into consideration.

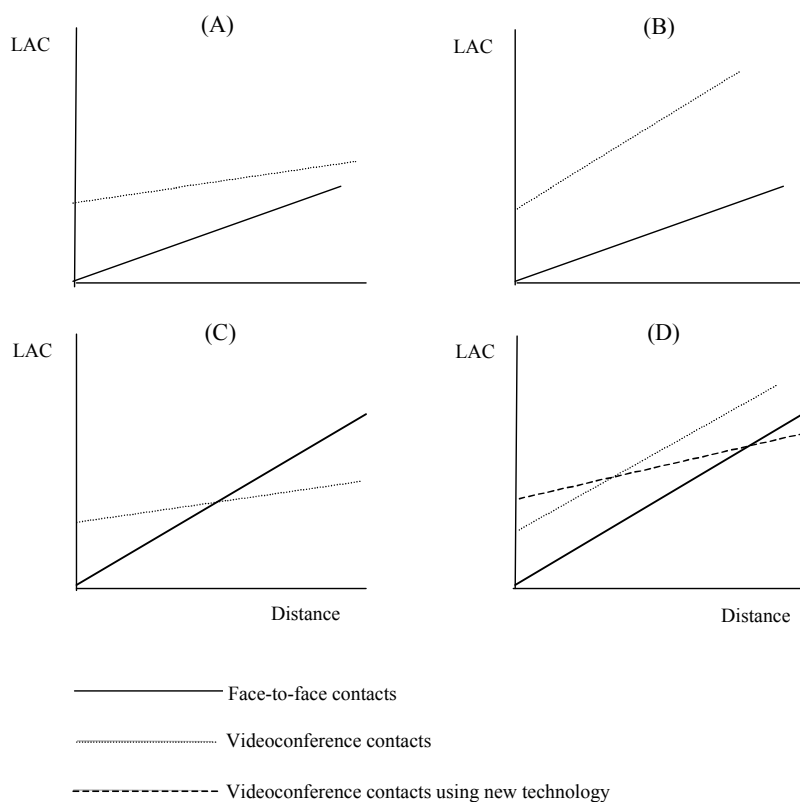


Figure 2.4 Telecommunications–travel cost trade-offs

Second, there is the question of exactly how important in practical terms are the relative items in each of the equations set out in Table 5.1? The evidence we have on this tends to come from stated preference studies (structured questionnaires and surveys) with comparatively little econometric analysis of revealed preferences having been attempted. Although not couched

exactly as one would like for exploring the cost models set out in the table, a study of both UK videoconferences users and non-users offers some insights (Table 2.2).

Those already using videoconferencing are inevitably most sensitive to the direct financial costs of use although, equally, the table also indicates a considerable potential sensitivity to the costs of alternatives – the costs of making physical contacts. Image quality – reflecting the efficiency of message and information transmission – is also a significant factor influencing the use of videoconferencing. Recent technology improvements, however, would seem likely to have reduced the importance of this issue. With respect to non-users, the direct cost factor is again important but equally so is access to the facilities and to links, in terms of easier hiring (not a problem perceived by existing users), and the quality of the facilities. There may well still exist a lack of confidence within this group as to the technical and service quality being offered at present.

Table 2.2 Factors likely to influence the future use of videoconferencing

	Not using videoconferencing		
	Not important	Important	Very important
Better quality images	4	4	1
Easier hiring of equipment	3	2	4
Transport costs	6	0	3
Costs of videoconference	3	2	4
Increased travel within company	4	3	2
	Using videoconferencing		

	Not important	Important	Very important
Better quality images	8	8	7
Easier hiring of equipment	16	5	2
Transport costs	7	4	12
Costs of videoconference	5	2	16
Increased travel within company	8	6	9

Note: Uses a sample of 32 undertakings – 9 did not use videoconferencing. Multiple responses were possible.

Source: Taken from Button and Lauder (1992).

Finally, the arguments set out above have been couched in essentially static terms but how inappropriate is this for new technologies? There is an established notion in management science that products go through a life-cycle. The classic form of the model assumes a sigmoid growth curve in sales of the product concerned followed by a decline (see the thin line in Figure 5.5). The product is initially launched but sales are low because of factors such as consumer unfamiliarity, lack of service facilities, high costs of non-mass production, technical unreliability, inadequate complementary infrastructure, and so on.

If it survives this phase then growth in sales occurs as consumer tastes are converted ('bandwagon' effects may also be initiated in some cases, for example when there are considerations of fashion), costs of production fall, sales outlets and service facilities expand in number, and standardization of technical specifications takes place. If the product involves networks of any kind then network economies can emerge that add impetus to the up-take of the product as more people have access to it; this may be a powerful effect in the case of videoconferencing as the benefits of equipment purchase rise as more potential contact possibilities emerge.

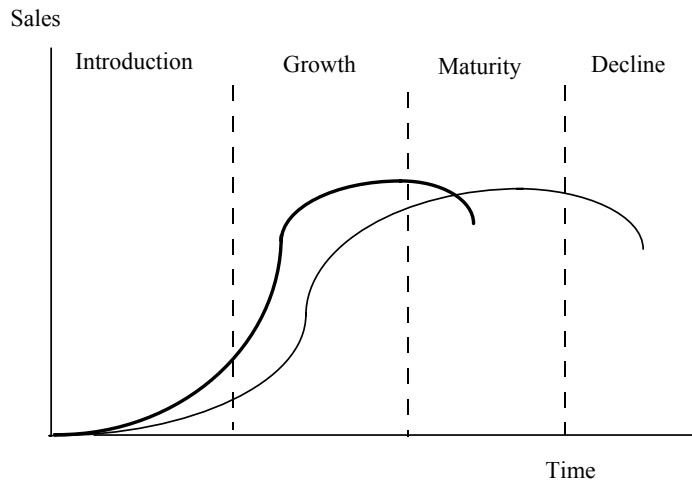


Figure 2.5 The classic product life-cycle

A mature market is reached when long run-marginal costs of production are minimized, product availability is virtually ubiquitous and near saturation of all potential users is achieved; the main market is for replacements. Finally, as new products come onto the market, and the market for the target product reaches replacement levels, so its sales decline.

While this classic framework has an attractive degree of simple and intuitive logic to it, its application to specific ‘products’ is less satisfactory. Studies have shown that the shapes of life-cycles vary considerably between products and services. While there is some evidence that more technological products, such as videoconferencing, tend to have a fairly long introduction phase, followed by a very rapid take-up and movement to maturity, the pattern is by no means universal. In particular, the move from the introduction phase to the growth phase is extremely difficult to predict.

This is possibly one reason for what, in retrospect, appeared as rather optimistic projections of videoconferencing use in the early 1980s. Essentially, those involved thought that the growth path would be similar to that shown by the thick line in Figure 5.5.

Videoconference use

What do we actually know about the uses to which videoconferencing is put? If one looks back only a few years the evidence was that videoconferencing was finding it difficult to move to the important take-off phase in Figure 2.5. In Switzerland, for instance (Magi, 1993), the amount of use made of videoconferencing either by the public videoconference studios (Figure 2.6) or by a Swiss multinational chemical firm with its facilities (Figure 2.7) was extremely limited and evidence of any significant growth was difficult to find. This picture gradually changed with time. The Zurich PTT, for example, and admittedly from a very low base, experienced a 3000% rise in the use of its studios between 1990 and 1991 with parallel growth in self-dialing.

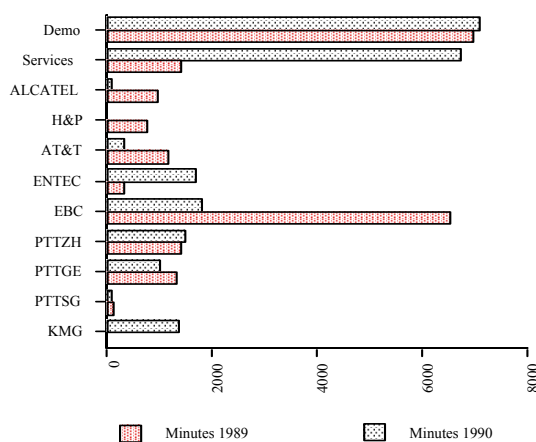


Figure 2.6 Videoconferencing in Switzerland (public studios, 1989/90 in minutes per year).

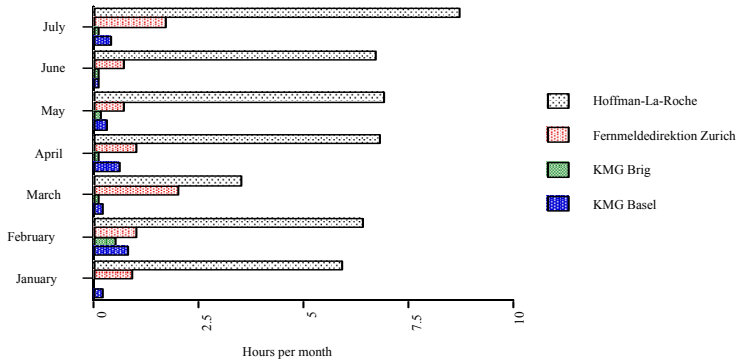


Figure 2.7 Videoconferencing by large Swiss chemical firms (hours per month, 1991)

Sudden, unforeseen, changes in circumstances also seem to be introducing potentially longer-term take-ups of videoconferencing. The Gulf War of 1991, for instance, led to many companies reducing or stopping employees flying and as a result videoconferencing use rose – for example, in the UK, BT experienced a 50% rise. A key point is that this once-for-all jump in use did not suddenly vanish but became part of the base figure.

The relatively low costs of transportation in the 1990s, partly as a result of deregulation of air transport in many countries, and generally rising incomes, however, tended to stymie significant further growth at that time. The uncertainties engendered by the attacks on the in 2001, the Second Gulf War, and the SARS outbreak provided a further upward jump in videoconferencing.

At the local level, mounting traffic congestion in many major cities and at airports adds to the uncertainty of travel.²⁶

At the more macro, and technical, level, one can look at the cross-elasticities of demand between transport and telecommunications by applying various econometric models of consumption to national time series data. Work of this kind is scant because of data limitations and problems of model specification. Salvanathan (1991) has attempted such an approach for the UK using the so-called Rotterdam modeling framework and employing times series data for the period 1960 to 1986.

While the work is aggregate, simply separating expenditures on private transport, public transport and communications, and there is no distinction by type of travel or means of communication, it is suggestive that the demand for communications over the period was highly inelastic (-0.12). Further, there is only a low cross-elasticity both between communications costs and private transport (0.08), and between communications costs and public transport (0.03). Similar aggregate work in the Netherlands (Netherlands Organization for Applied Scientific Research, 1989) also yielded low elasticities and suggests that adoption of telecommunications over the next 35 years will only reduce traffic by 8%.

Of course, it would be inappropriate to directly apply these elasticities to videoconferencing, especially when looking at the significant price falls that many in the industry are still suggesting as possible in the future. The change is not marginal and it is unrealistic to anticipate fixed elasticities over anything but a relatively limited price range. However, in absolute terms, if this

²⁶ There was also a major upsurge in the use of teleconferencing during the early years of the twenty-first century as a cheap and flexible means of conducting business without the need for specialized equipment.

elasticity were applied to, say, a fall of 80% in the costs of communications then private transport use would fall by 10%.²⁷

Looked at another way, in Great Britain the number of trips made as part of work travel would have fallen in 1985/86 by 0.044 per person per week which aggregates to some 114.4 million work trips per annum – given the nature of the substitution effect and the greater incentive to switch communications mode when longer distance interactions are involved, the actual impact on mileage traveled would inevitably have been larger.

POTENTIAL TRANSPORT EFFECTS

The overall take-up of videoconferencing, as with the larger concept of telecommuting, is seen to have potential implications for the transport system (although not always those of reducing demand) but equally it has possible implications for internal industrial organization, the nature of office architecture, and the location of economic activity. It can also affect the comparative advantages of different locations. These aspects of telecommunications have, though, been less thoroughly explored than the implications of the ability of people to work at home. At the micro level, for example, there is evidence that use of videoconferencing tends to vary between companies. Relatively little work, though, has been conducted, either at the theoretical or empirical level, on this aspect of the subject.

²⁷ This assumes there is no, what traffic engineers call ‘latent demand’ for road space. Put another way, as trips are transferred to videoconferencing there may well be people who make additional trips as the level of traffic declines thus reducing the time cost of travel. This in turn pushes up the congestion level thus increasing once again the time cost of travel.

In the past, the slowly increasing use of videoconferencing has often been seen as a way of reducing the costs of work-based travel. Johansen and Bullen (1984) and Salomon (1986) have pointed to the increased awareness by companies of travel costs, including time as well as money costs, and are able to compare these directly with the costs of investing in videoconferencing facilities.²⁸ In practice, however, the situation is more complex and at the level of the individual company the impact of videoconferencing is seen by several studies to depend on a number of factors.

In the first place, companies vary in the degree to which they systematically cost alternative methods of communication. Some undertakings, however, with in-house videoconferencing systems also operate accountancy procedures to determine when it is cost-effective to replace personal travel by a videoconference. IBM in the US has an on-line system to inform managers throughout the world of the comparative costs. In the UK, GPT, which has an internal videoconferencing system linking its main sites, equally provides details of comparable costs. The costing of the video facility is based on full cost recovery.

Further, some studies suggest that videoconferencing will be used to conduct many types of meeting not previously carried out face-to-face using transport modes (Johansen, 1984). In other words at least part of the demand will be newly generated interactions.

Where there is some potential for transfer, evidence from UK studies is that personal contact is still necessary. For instance, while some 34% of meetings recorded could have been performed by audio only conferencing and a further 10% through the use of video systems some 50% of

²⁸ In a way this may be seen as a labor market parallel to the up-take of supply chain logistics in the freight-inventory market.

communications still required face to face contact (Pye, 1976). Bennison’s (1986) early work in the field highlights the potential complexity of underlying relationships involved. His study of a field trial in the UK found that in companies where videoconferencing had become established it had become a complement to face-to-face contact meetings. This confirms findings in Mokhtarian’s (1988) US study in Southern California. The indications are that videoconferencing may generate additional trips even if it reduces the average trip length.

To a considerable extent the degree of complementarity or substitution between travel and videoconferencing will depend upon the uses to which videoconferencing can be put within a company, the external environment in which a company operates and the internal managerial structure of the company. Only limited evidence is available on any of these points.

Regarding use, Button and Lauder’s (1992) study of UK users found that there was evidence of explicit travel replacement. This was both for domestic and international trips, but no evidence was gained regarding either directly generated additional travel related to the other uses being made of videoconferencing or as a result of time and cost savings brought about by the substitutions which were recorded – see Table 2.3.

Table 2.3 Uses made of videoconferencing in the UK

	Used	Used frequently
In-house training/education	1	2

External education	4	5
In place of international travel	1	3
In place of travel within the UK	2	14
Internal communication	5	9
Communication with other companies	8	9
Setting up video conferences with others	7	1
Other purposes*	4	4

*Use in design and development and for demonstrations were both mentioned twice.

Source: Button and Lauder (1992).

Concerning the external, commercial environment in which companies operate, if we look at the up-take of videoconferencing in Switzerland we see from Table 2.4 that some types of company have adapted more rapidly to its availability than have others. The earliest users, from 1986 to 1989, were mainly multinationals, often with strong US markets or with experience of US equipment. This initial pattern of up-take conforms to what one would anticipate from the product life-cycle model set out earlier in Figure 2.5.

The types of firm initially using videoconferencing in Switzerland tended to have experience of it elsewhere and hence be part of an intra-firm network which removes many of the problems of product familiarity and lack of complementary infrastructure (divisions in other parts of the world already having equipment). They are also large enough in most cases to justify the use of older, less mobile and flexible videoconferencing technologies.

Table 2.4 Users of videoconferencing in Switzerland

Innovators Rapid	Major	Slow	Not
------------------	-------	------	-----

	adopters	users	uptake	using
DMF	Alcatel	ABB	CICR, DFAE	Alusuisse
	DEC	Caterpillar	Mövenpick	André & Cie
	Du Pont de Nemours	ITC	ONU	Danzas
	Hewlett-Packard	Lausanne	Palais	Kuoni Maus
	Hoffmann-La Roche	Nestlé Business Park	Universités	Féséral Frères
	IBM	Swissair		Pirelli
	Sony	Tetrapak		SGS
		UBS		Edco,

Source: Adapted from, Perret-Gentil et al (1992).

These multinationals were followed, via a demonstration type effect, by a heterogeneous collection of large Swiss based companies. The official, administrative and educational sectors, which function in an essentially domestic environment, have been rather slower to adopt videoconferencing. They have less experience from outside involvement and this increases the initial impetus to invest in an uncertain product. In other sectors of industry the up-take seems also to have been slowed by the lack of a critical network scale. (For a technical explanation of the benefits of network size, see Katz and Shapiro, 1986.)

Regarding internal company structure, the available evidence is extremely limited, in part because defining business organizational structures is itself a difficult task. Some general points, though, can be made. Figure 2.8 provides some of the standard models of organizational structure of business firms.

As a caveat, it should be remembered that there is an inevitable link between the internal structure of firms and the external environment in which they operate. Multinationals, for

instance, which we saw from Table 2.4 were early users of videoconferencing in Switzerland, often have hierarchical or semi-independent unit structures. This makes isolating the independent effects of the external environment from that of company structure difficult.

How videoconferencing influences the face-to-face contacts that take place between the various elements in each form of company structure will, in part, depend on the geographical dispersal of plants, units and so on within a company coupled with its overall size. With larger companies serving large national and multinational markets the structure itself is of greater significance. Essentially face-to-face or videoconferencing contacts within an organization serve a bridging function. The nature of the bridge, however, relates back to the elements in Table 2.1.

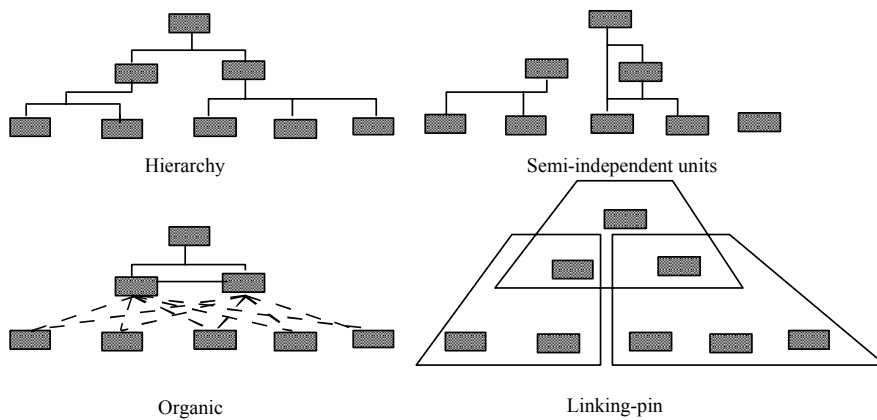


Figure 2.8 Examples of organizational structures

In general, videoconferencing is less good at handling complex messages and where there are significant fixed costs (I) relative to subsequent utilization costs. This suggests that its most

likely use is at lower-middle levels of companies where, as we see from Figure 5.8, in virtually all organization structures there are larger numbers of contacts and where the level of information to handle is less complex. There are, though, probable caveats to this. In the semi-independent unit structure these economies of density are markedly lower and it is this type of industrial structure that seems to be growing in some sectors (in part to enhance flexibility and nimbleness of undertakings). It is also less clear how videoconferencing would fit into the link-pin structure where the information flows tend to be rather more focused on subordinate managers than enhanced notions of hierarchical powers.

FORCES FOR CHANGE

Some of the changes that we have noted in the UK and Switzerland, such as the growth of interest in videoconferencing during the two Gulf Wars, should be seen as exogenous shocks to the system. There are in addition a number of internal developments that are increasingly adding to the up-take of the media.

Changing attitudes of business towards the automobile

Returning to our product life-cycle model, any product gains a market both by attracting new users (business creation) and by taking users from other products (business diversion). In the case of videoconferencing, the diversion effect is likely to be primarily from business trip

making and from audio conferencing. There has, in the recent past been a very rapid increase in business travel, and in particular that undertaken by cars.

The pressure to switch to videoconferencing has been softened in many countries both by the taxation structure regarding company cars and by major road building projects that have limited the build up of congestion on trunk roads. The generalized costs of business travel have, therefore, been kept down although this is now changing and not simply because of rising fuel prices from 2003. For example, a survey of 75 managers of UK companies conducted by the Kristal Corporation in 1991 found that 91% felt that business travel now disrupts work routine and increases stress as well as interfering with family life. The problems of travel caused 21% to lose their temper, 20% to perform badly, 16% to have disturbed sleep, and 13% to take solace in alcohol. While these factors are beginning to exert short-term pressures, in the longer term the types of problems outlined are likely to worsen if traffic growth even approaches the levels forecast.

More user friendly equipment

While many products offer what appear to the manufacturer to be considerable attributes in a purely technical sense it is often user friendliness that is a key consideration for widespread adoption and use. In the case of videoconferencing, this may be viewed in terms of the individual users' reactions to the product and the degree to which the product fits in with the wider activities of the firm. Early equipment involved studios that, while offering many diverse

technical features, often proved alien and intimidating to users. It also involved complex arrangements for booking time that reduced its flexibility for managing work patterns.

These limitations are now rapidly being overcome as equipment becomes more mobile and it is much easier to arrange video meetings and get the specific types of service attributes desired. Videophones, for instance, are now becoming available, albeit at relatively high prices, and the providers of videoconference facilities, such as the Swiss PTTs, are recognizing that public studios may not provide the ideal way forward. In particular, systems such as the Swiss MEGACOM facility launched in 1992 with its self-dial, wideband features, facilitate easier access to the network. Further, where additional features are being incorporated, they are often facility specific (such as sophisticated electronic encoding devices to limit 'eavesdropping' on confidential conferences) and are essentially purchased as add-ons rather than being charged for irrespective of use.

Links with other technologies

Videoconferencing is only one element of a range of technical possibilities in the telecommunications field. Its widespread adoption and speed of take-up will, to some extent, be influenced by the up-take of other telecommunication systems (for example, telecommuting, teleshopping and distance learning). This synergy effect stems from the degree to which the actual cost of videoconferencing is likely to fall as economies-of-scope can be realized by suppliers of telecommunications facilities as they supply a variety of different but linked

products. And also from the reduction in user resistance to videoconferencing as people become more familiar through usage with advanced telecommunication systems in general.

Enhanced reliability

Product take-off requires confidence on the users' part that the service sought will be forthcoming in a reasonably reliable fashion. The early UK system Confravision, for example, suffered from having to use standby television relay circuits. These problems have now largely been overcome and, in any case, the growth in traffic congestion, with its associated impact on reliability of person movements, has changed the point of comparison.

Lower costs

Cost is obviously a primary consideration to business users of telecommunications. In the past complexity kept the price of videoconferencing units high but economies of large-scale production are rapidly bringing these down.

There are two main elements of equipment cost which need to be considered with respect to videoconferencing. First, there are studio costs. Mobility is a relative thing and some current 'mobile units' are in fact far from easy to transport about buildings but they may be used in virtually any type of room. In particular, this means that dedicated studios are no longer required for most forms of conferencing. The new generation of codex is now much smaller than previously and some of the new configurations of equipment take up little more floor space than a

desk. The reduced need for studio facilities is also likely to lead to lower labor costs in operating a videoconferencing system within an organization.

Second there are equipment costs *per se*. These have fallen considerably and are forecast to fall very dramatically over the next few years. There are suggestions from those involved in the industry that while portable units in the US in the early 1990s cost in the \$30 – 80,000 range (while full dedicated studios can cost \$200,000 although this, in real terms, is about 80% lower than in 1981) fell to under \$7,500 by the mid-1990s. This is mainly because of economies of scale in production that accompany higher sales as international agreements on standards for interactive video compression are reached and product uniformity increases.

Line costs are the main elements of costs associated with videoconferencing – at present codex costs amount to only about 25% of the lifetime costs of a videoconference network. They are, however, falling dramatically. At the international level, renting time on satellites in the US dropped from about \$8,000 per hour in 1981 to less than \$300 by 1993. The investment now taking place in fiber optics and the increased capacity of satellite systems is likely to bring these costs down further. Within Europe, costs tend to be much higher than in the USA and in most countries there is central control by the national PTT. Increased competition and the liberalization process, however, are gradually changing these pricing structures.

One option where a company does not have its own videoconferencing units, and probability of the rapid creation of a significant network of likely contactors is remote, is to hire or lease the service and here costs have again fallen considerably in competitive markets such as the US. Conference Express charged in early 1991 between \$750 and \$900 for a one hour meeting

between two US cities, \$1900 per hour between New York and Paris, \$2500 per hour between New York and London and \$3300 per hour between New York and the Far East. On average these charges represented a 60% reduction for domestic videoconferences and a 75% reduction for international videoconferences from the mid-1980s.

Standardization

Very seldom does any product gain rapid market assimilation without either some implicit or explicit sets of standards being arrived at. Without such standards equipment cannot interface efficiently, economies of scale in production cannot be achieved, training poses a problem and service and maintenance costs are high. As has been demonstrated with many products the standardization does not have to reflect the best ultimate technology – one might wait forever for this – and may have serious limitations in the longer term as demand patterns change and technology advances.

Standardization is likely to both bring down the hardware costs of videoconferencing as well as opening up many more opportunities for inter-organizational video meetings. There is always a trade-off when setting standards between an early introduction of a standard, to assist in bringing a focus to development and design, lower production costs and simplify communications, and a later introduction of a better standard, once more of the technical developments have taken place.

The efforts at present, while accepting the potential for improved technology, are tending to focus mainly on the creation of universal standards that it is hoped, will assist in the more rapid

up-take of videoconferencing. In the early 1990s the International Telegraph and Telephone Consultative Committee introduced a new standard and manufacturers moved to implementing P*64 hardware and software in their videocodecs. There is also discussion of a new standard for multi-way video that seems likely to be accepted in the near future. Such standardization offers both potential for improved quality of picture at any bandwidth as technical developments can be pursued within known parameters and also a wider range of product qualities as equipment at different bandwidths are tailored to meet specific requirements.

Videoconferencing depends upon the availability of adequate and appropriate links between the users' stations. In the past pre-booking systems were required although ideally a public switched service is required to facilitate easy use. At present this does not exist on a European-wide, let alone on a global, basis although the situation is changing as, for instance, we noted in Switzerland.

CONCLUSIONS

The early optimistic forecasts that videoconferencing would provide, in a very short space of time, a popular and widely used telecommunications instrument for business that would reduce the need for travel to face-to-face meetings were not well founded. In particular, such predictions ignored, on the supply-side, the inherent limitations of the infant technology available, the socioeconomic difficulties of converting to the new media and the high costs of use while, on the

demand-side, the capacity of conventional transport modes still provided reasonably reliable and efficient means of facilitating face-to-face contacts.

These forecasts also ignored the possibility of other new technologies that would find a market niche much more rapidly, such as the facsimile, and have tended to divert resources away from videoconferencing. One must also add that the external benefits often derived from business travel (visiting new places, making new acquaintances and being out-of-the-office) may well have been underestimated in these predictions.

The take-off has, therefore, been almost painfully slow. More recently, however, there are signs in the UK and Switzerland, both that many of the underlying parameters are changing and that there is beginning to emerge a more dynamic market for videoconferencing services. Whether this is a genuine take-off and whether it will exert any major influence on business travel is still, though, far from certain.

Given the hindsight of experience in this field, predictions about future trends are perhaps best avoided. What we do find, however, is that there is considerable potential for telecommunications costs to fall in the near future and with them the costs of videoconferencing. The quality and user-friendliness of equipment are also likely to improve. Evidence from users and non-users in the UK suggests that a combination of such changes combined with increasing costs and frustration with the transport network could lead to a greater use of videoconferencing. If so, however, it is extremely unlikely to provide an answer to problems of mounting traffic congestion and pressures for more transport infrastructure capacity but it could help to reduce the intensity of such problems.

TELECOMMUNICATIONS AND THE “NEW GEOGRAPHY”

INTRODUCTION

Most of the discussion of the interaction between transportation and telecommunications has focused on essentially short- and medium-term considerations; the effects of teleworking on commuter traffic, the role of informatics in making better use of roads, and the importance of modern communications systems in shaping just-in-time production management. From a political perspective this is understandable; there are a variety of pressing social and economic issues that need addressing at this time.

There are, however, indications that over the medium- and long-term the changing roles of transportation and telecommunications may have fundamental effects on the way land is used (Abler, 1975). This is not always a matter of governance changes, but rather that for technical reasons it takes time for land-use patterns to change; there are often ‘stranded’ costs associated with leaving on old location, and search costs for new sites can be time consuming.²⁹

Technology has shaped the physical landscape over the centuries, and been a consistent determinant of human land-use patterns. The ability to control fire changed methods of hunting, and then allowed for agriculture to develop. Stone Age technology led to the extermination of many animal species that had trickle down effects on the plants that grew. Moving rapidly

²⁹ This is not to say that there have not been changes in governance. For example, with the increased physical mobility in US society that, most would agree, has been in part due to the shift to a more service oriented economy, there have been changes in the ways housing may be financed.

forward, as components of this technology pressure, communications and transportation technologies have been key elements in the way that human geography has evolved and in the way in which we live. Whether the technology changes have been the consequence of necessity, or have themselves been drivers is a topic of endless enquiry.

The nature of the links is certainly extremely complex and still not entirely understood; not least because the forces at work have not been constant over time. The result is that there are very many issues involving, in particular, directions of causality that still stimulate considerable debate. The links can also involve a number of intervening and interacting steps via things as diverse as public health and mechanisms of political control that make specification of analytical models challenging. Added to this, land-use has been a subject of public intervention and markets are inevitably far from perfect. This makes empirical investigations and appraisals problematic even today in the age of global information systems (GIS) that provide an abundance of spatially coded information.

Intellectually there have also been significant changes in the way many economic-geographers now view the forces that influence the economic development of various regions, and with this the spatial distribution of activities; we have moved into the era of what is often called the 'New Geography'.³⁰ This shift reflects two wider trends in economics.

The first is the increased technical rigor that has found its way into the discipline and allows greater clarification in the tracing out of cause and effects. The second is the move away in many pieces of analysis from the assumptions of neo-classical thinking with its focus on perfect

³⁰ These developments mirror larger changes in economic thinking that have involved such creations as 'New Growth Theory' and the 'New Institutional Economics'.

markets, to embrace more realistic such as indivisibilities, various forms of scale economies, asymmetric information, and game playing by individuals, public institutions, and firms.

These changes have been paralleled, and from the perspective of empirical testing, supported by new quantitative analytical tools that allow for the explicit statistical problems associated with cross-sectional analysis of data across physical space; ‘Spatial Econometrics’. Added to this, there has been something of a resurgence in interest in the role of institutions shaping production and consumption patterns, including their spatial distribution. Traditionally, with the exception of a small group generally seen as at the periphery of main stream economics, institutional structures (including informal institutions as well as legal contracts) were not considered important by economists. Those taking the opposite position, it should be said, did not until recently help their case by being largely antagonistic towards their main-stream brethren rather than putting forward a coherent and rigorous theory of the role of institutions.

But first let us look at some background on the way links between communications, transportation and land-use have evolved over time. Land-use patterns change slowly, and legacy effects are seen everywhere, but recent times have witnessed more dramatic changes than ever before and it is helpful for a fuller understanding of the forces at work, and the constraints in play, to take a longer perspective.

EARLY DEVELOPMENTS IN LAND-USE PATTERNS

Some history

The hunter gathering societies of 5,000 years or more ago lacked the technology to store food or ensure a constant flow of substance at any particular location. Concentrations of populations were simply not efficient for more than a few families. The control of fire helped hunters and offered enhanced abilities to pursue their food gathering but at the same time destroyed local woodlands and pastures necessitating continual migrations. It may have enhanced the tendency for families to group more but not for permanency of communities.

There are debates about its origins but agriculture and animal husbandry changed this way of life and introduced more permanency in people's life-styles. The plough allowed large-scale arable farming and the creation of production surpluses that stimulated urbanization. This in turn was reinforced as larger social groups formed and conflicts emerged; towns and cities became safe havens. The size of city-states remained small, however, limited by the productivity of the surrounding hinterland and the ability to transport food from it. Additionally, communications between these unitary entities was poor, and trade limited and difficult.

As nation states emerged, and empires grew, change took place. Communications became more important as an element of political control and as a necessity for military mobilization. Smaller towns grew as essentially communications service stations providing staging points for riders and runners, and at sea as victualling points for ships. Improvements in roads and wagons and in the logistics of the moving written communications (e.g., early state postal services)

allowed gradual refinements to this structure, but in essence it remained unchanged until the Industrial Revolution. Transport and communications were slow and unreliable until well into the Industrial Revolution.

The canals, more efficient sailing, and then steam vessels and the railways initiated an age of faster transportation, and perhaps of greater importance, reliable major infrastructure initiatives, such as the Suez and Panama Canals, that provided the basis for modern global commerce.

Industrialization also brought about modern cities and subsequently metropolises. Cities had largely grown up as safe havens surrounded by walls or located in easily defended terrain. The inability to store fresh food or gain access to potable water, together with a poor understanding of hygiene and public health, generally made them unattractive places to live. There were clear trade-offs, therefore, for individuals to make. Their average age of people, and their physical structure (including height), seems from archeological evidence to have fallen as urbanization occurred; a pattern that persisted to the early part of the twentieth century.

Changes came to urban life in the mid-nineteenth century as improved sanitation reduced the incidence of many diseases and more generally made cities more habitable. Housing design and construction improved and, into the twentieth century, the arrival of electricity reduced pollution and transformed living in apartments and small urban houses.

More recent times have also seen the on-going developments in telecommunications, and their interactions with transportation, having a somewhat different impact on the contemporary human geography landscape (Kotkin, 2000). Improved local transport – trams, metro systems,

buses, and the automobile – increased the length of commuter trips, and with this brought about changes in urban geography. In a different context, developments in military transportation and military communications have altered the ways wars are fought and the protection offered by large cities has vanished as a result.

Underlying patterns

While there are some specific features in this history some generic and fairly robust things also emerge. Patterns of location are shaped by technology, for example, in at least two important ways. First, the technology itself makes use of land and affects the way economic production is undertaken. In the transportation context, the move to large sea-going ships produced ports and fostered trade. The advent of the railways, by enabling rapid, reliable, and relatively cheap movement between distant locations, fostered the concentration of economic activities at nodal points in the system – they rapidly developed hub-and-spoke systems. These nodes, both ports and railway centers, were limited in their impacts on local urban form until the development of the tram, the bus, and local truck distributor systems.

But there is also a second way that location is influenced by technology. All forms of technology require inputs of various raw materials. The building of early mercantile fleets denuded much of the Mediterranean shores of timber and the quest for food at sea led to the extinction of the dodo. The railways required coal and steel, and, in the US case, the local bison were nearly exterminated to feed the construction teams. This led to a second location force, that

of productive concentration around these sources of raw materials – the mining and steel towns in the rail example.

The information age has not changed these fundamentals but what it has done is to introduce new variables and parameters into the equation and modified some of the traditional ones. The importance of place and location is increasingly being seen not only in terms of physical factors, either raw materials or man-made infrastructure, but more in terms of concentrations of human skills in densely populated areas.

The traditional neo-classical economic theories of location focused on raw materials, technological advantage, and physical access. The latter, however, was a twin-edged sword. Setting aside the particular issues of natural resource based spatial concentrations, access enhanced the potential of a location but at the same time encouraged migration into an area. Internal mobility within the region would decline as congestion costs increased and land values at the best locations increased. This in turn would reflect back on higher transportation costs.

Because of this decline in comparative advantage, investment would leave the area to seek other locations where congestion was lower. The outcome would be a gradual evening out of production across space, although this may take generations rather than just years.³¹

Some of the more recent ideas concerning information-based activities suggest there is much more of a proclivity for what has in the past often been called ‘cumulative-and-circular causation’ in the macroeconomics literature. Essentially the idea, often associated with Gunnar

³¹ There are some exceptions to this view. Kaldor (1970), for example, suggested that, because of economies of scale and of agglomeration in manufacturing that outweighed congestion cost effects, there would be a tendency for growth to expand in areas that already had a strong industrial base.

Myrdal, is that, because of scale economies, wealthier areas simply get wealthier and poorer areas even poorer

The modern variant of this theory is less driven by industrial scale effects of the traditional kind, and more by the ability of technology-rich areas to continually up-grade their information base. Basically, the argument is that modern 'high-technology' industry is footloose in that it does not rely excessively on traditional spatially immobile inputs. In particular, the choice of location for a firm is thus much more elastic. Since firms and individuals are not homogeneous this provides more scope for electing to locate in places that offer the best portfolio of desirable features. In terms of the service sector, for example, the geographical concentration of share trading at Wall Street is no longer necessary.

This does not necessarily mean that there will be an even spread of activity across space but rather that location choice will alter, and is indeed is already altering. There is near agreement amongst geographers that there will still be concentrations of economic activity but they will be in different places and of different forms.

Much of what is happening in terms of the spatial pattern of economic activities, both production and consumption, is being influenced by interactions between telecommunications and physical transport movements. Urban forms, for example, are no longer as simple as once thought and in part that is due to changes in telecommunications and transport.

TRADITIONAL MODELS OF TRANSPORT AND URBAN LAND-USE PATTERNS

Traditional urban forms

Economists have, as we have seen earlier, paid relatively little attention to the interactions of transportation, location, and information flows until comparatively recently; Wise (1971) being an exception. Production and consumption in many analytical economic modes are treated as taking place on uniform, boundaryless plains. Land is seen as a factor of production but largely treated in terms of its output potential when combined with labor and capital with scant regard for its location.

Much of the early interest in land-use patterns, at least those that had a transport element in them, had to do with agriculture – von Thünen’s work on the influence of distance on production in the mid-nineteenth century being the best known. These theories focused on the weight of produce and their transport costs; everything else being equal you grow the heavier crops nearer the town or village where they are to be consumed.

More germane to the core of this book are the translations of the underpinning of this work into theories seeking to aid in the understanding of urban form, and the domains of cities.³² It must be said, however, that this understanding is still far from complete and without a coherent

³² Much of the current analysis of urban form, size, and size distribution stems from the emergence of the ‘New Urban Economics’. Until the late 1960s and early 1970s urban economics tended to be largely descriptive and institutional in its nature, and was mainly concerned with specific problems involving such things as urban transport, housing, and public finance. The New Urban Economics represented the introduction of more rigorous and consistent tools of microeconomics that provides holistic framework within which urban issues may be analyzed and public policies can be developed. Hirsch (1973) provides a somewhat dated, but good account of these developments.

framework discussion of the interactive role telecommunications and transportation play in shaping city form and size is inevitably rather piecemeal.

Translating the basic von Thünen framework into a theory of urban form gives us the concentric pattern of urban land-use abstracted in Figure 3.1. Local transportation is ubiquitous (and with this communications flows are ubiquitous), in the sense that there is a constant cost per mile of traveling, and expensive. This combined with agglomeration economies from companies situating in proximity with one another, results in production and jobs being focused in a central business district.

The central business districts themselves tended to grow considerably in nineteenth century and expand as commercial centers. But in doing so their forms changed. The advent of improved communications was one factor that fostered this, as first reliable postal services grew and then, perhaps more important, the telegraph emerged.³³ This allowed information on fashion and news to flow more freely and rapidly, stimulating retail activities, in particular, to expand and concentrate at urban centers. Only larger stores, however, were in a position to fully exploit this, adding industrial concentration, with moves to the ‘super stores’ of the time, to that of spatial concentration; by 1900, for example, there were over 1,000 department stores in the US. The location of these stores, themselves, influenced the shape of the central business district as well as the land-use surrounding it.

In these concentric cities, those with lower incomes tend to live around the central area to economize on transportation outlays. Many large cities in the nineteenth century were, and some

³³ Standage (1998) talks of the telegraph in terms of it being the ‘Victorian Internet’.

remain, major recipients of immigrants, both domestic and from other countries, and this led to special concentrations of various ethnic groups within these income rings. The resultant rise in land-prices from this spatially focused demand leads to high populations densities in the inner zones as poorer people also economize on the amount of residential land they rent or buy (apartments being common). Middle-income groups can afford to spend more on transport and on land and, in consequence, tend to live on larger plots further out. The wealthiest groups live on the edge of cities to avoid the congestion in the center and commute to work; the costs of travel being a relative small part of their income and greater flexibility in work hours often allowing them to avoid rush hour traffic.

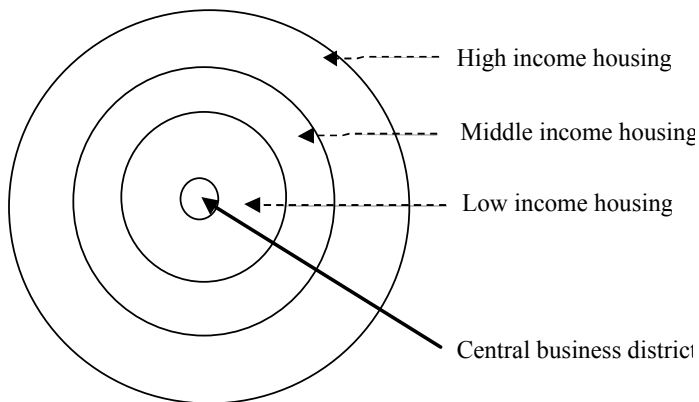


Figure 3.1 The ‘concentric’ pattern of urban land use

The advent of mechanized transportation, initially the trams and suburban rail systems and then the automobile, affected the relative costs of access within cities. The concentric city

was focused because of the centralized orientation of long-distance transportation. But then local transportation improvements, for both passenger and freight movement, emerged. Close proximity to trams lines or suburban rail termini, and then major arterial roads with bus services offered significant savings in generalized transportation costs. The result was a distortion to the concentric pattern of urban land-use with residential areas expanding out along the new transportation arteries; the early appearance of suburbs. The axial pattern of land-use emerged (Figure 8.2). The star-shaped pattern still retains the various zones of income groups but each is extended out along the transport arteries.

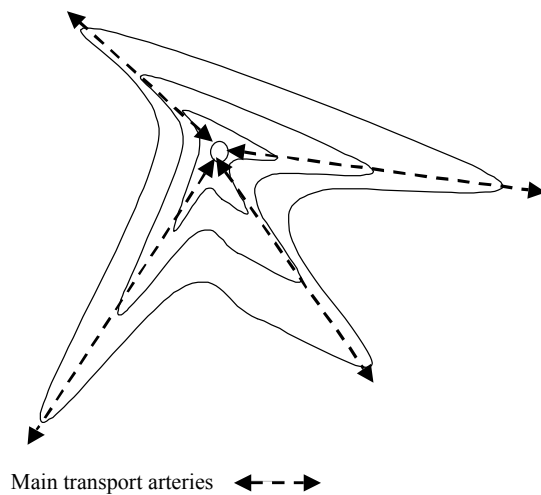


Figure 3.2 The 'axial' pattern of urban land use

The more contemporary trends, initially in transportation and more recently in communications, have led to somewhat different patterns of urban land-use that have in many instances been reinforced both by prevailing land-use planning policies and by changes in the industrial bases of many cities. Automobiles have afforded greater mobility for locations away from the main arteries. Production technology has moved towards more emphasis on the horizontal layout of plants and away from physically vertical processes; 'greenfield' sites have become attractive. They also offer space for parking provision and for 'work-related' social facilities; golf courses and the like (Button, 1988; Johansson and Westin, 1987).

The result of this has been the emergence of multi-nuclei cities where the land-use pattern is less focused on a central business district and more on a number of specialized sub-centers – e.g. business parks, educational complexes, leisure and recreational areas. Housing estates, while often socially separated, tend not to be in zones around a core but rather in blocks or groups, often with supporting social infrastructure. This is not a new pattern entirely, but this type of spatial concentration tended to be more of a micro-feature of land use within central business areas (e.g., many central areas have long had their business district, their market district, the theatre district, and so on) where various forms of agglomeration were important. New forms of production and goods, combined with changing tastes and income, have expanded scale effects and added new ones.

Advances in telecommunication should perhaps be seen more as a facilitator of this trend than a strict driver; the main forces for this pattern of land-use being more in terms of widespread automobile ownership and changes in the types of goods produced and the

production management adopted (Harkness, 1974). Improved telecommunications has allowed it to evolve more efficiently. On the demand side, rising middle class incomes and pollution in many cities led to an outward exodus away from locations around the core.

But it has also been a function of conscious land-use planning policies in many cities where authorities have sought to internalize many of the external economies of production. They have also often been driven by social motivations involving improving the housing stock for the poorer groups in society and making available more communal services. This has not always worked, however, as seen in the move away in the 1990s in many cities from the large residential estates that were constructed in the 1960s. Added to this, have been privately ‘master-planned’ cities – almost self-contained communities in terms of leisure activities and shops, such as Irvine in southern California and parts of Houston – that cater more for the higher income groups seeking security in numbers as well as high-technology employment opportunities.

Edge cities

More recently Garreau (1991) has highlighted further changes in the form of the emergence of ‘edge cities’. Whereas multi-nuclei constructs involve a number of highly specialized centers, edge cities, in contrast, are self-contained social and economic entities that have emerged adjacent to or within the boundaries of older cities; Tyson’s’ Corner in Northern Virginia may be seen as an edge city of Washington DC. They have ties to the longer established entities but are largely independent of them.

Figure 3.3 offers a very simple idea of what the mapping of an established major metropolitan location with an associated edge city may look like. It assumes concentric patterns of land use for simplicity, although many edge cities actually grown on major transportation arteries leading from the legacy area and are in effect located on arms of what may be seen as an underlying axial city land-use configuration. The figure also simplifies the interface between the various land-uses where the old and new cities merge; for example, because of alternative employment opportunities in the traditional core or the core of the edge city there may be ‘corridors’ of residential areas that feed through the rings of income categories.

These edge cities contain their own employment base, retail and a diverse range of housing. Often there are complete ranges of social services – hospitals, schools, and colleges as the local tax base is strong enough to support them. Because they are more recent constructs, or have taken land that formed part of the traditional city catchment area that had a lower economic value, there is an inevitable tendency for the edge city to have more service related and technology jobs, than the older city.

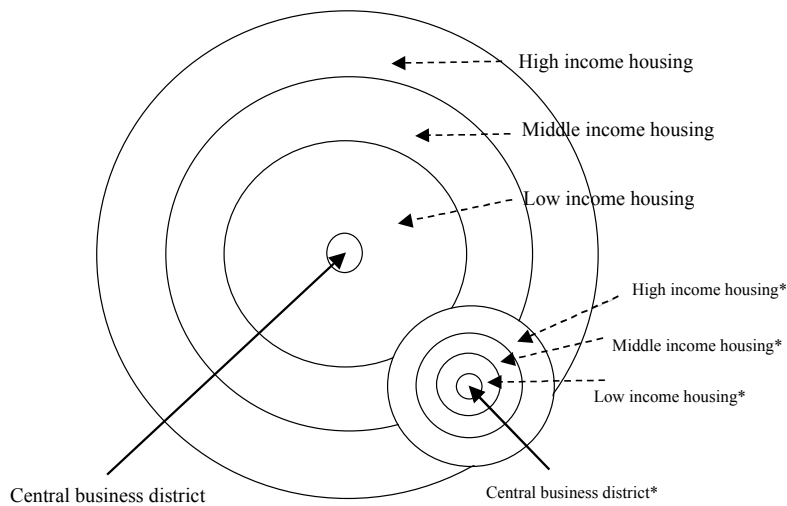


Figure 3.3 Simple representation of the edge city concept

The negative impacts of traffic congestion, high crime rates, and the poor quality of the environment, that are often found in the older core have inevitably contributed to their formation, but so has the positive growth of the service sector (Higano and Shibusawa, 1999). Services, as we have seen, now dominate employment in most developed economies and many service-based industries are heavily dependent on telecommunications. It is this type of industry that generally forms the economic base of an edge city, and even if there are other forms of employment these are often tied to information-based activities.

There may also be other reasons to anticipate the continued growth in edge city type activities and that is to do with the structure of the emergent logistics of many forms of activity.

In the case of the majority of e-retailing the major players focus their operations around massive ‘fulfillment centers’; in the US Land’s End has such a center at Dodgeville, Wisconsin that is the size of 16 American football fields. Since these centers need have no physical link to Web servers, but require good access to freight transportation arteries with minimal local congestion, they often locate in proximity to but outside of large cities. Given their employment potential, they may form another nucleus for the emergence of an edge city.

Systems of cities

What this sort of analysis does is provide some basis for explaining the internal spatial structure of cities; what it does not do is explain either why individual cities are located where they are or the relative size of different cities. In the past, technical limitations of transportation and the inability to store agricultural surpluses provided a simple explanation of why cities emerged where they did. This type of rationale is much less strong in modern industrial economies, although an inevitable legacy effect remains.

At one level, while there have been numerous empirical investigations that have shown cities are not simply random occurrences in space but seem to have some pattern to them, there are debates that can be traced back to the 1950s focusing on what produces ordered relationships between urban areas. Not all, however, even agree on the nature of this distribution. Some when ranking cities by population have found that the resultant spread conforms statistically to a Pareto distribution, but others have found a rank size distribution. This type of analysis is essentially descriptive, however, and more concerned with clarifying data than explaining it.

One school of thought aimed at offering an explanation for urban hierarchies, has traditionally looked outside the cities in the sense of being concerned with markets for the goods and services that cities produce, and seeing them as exporting entities growing in line with these external demands. Another school places emphasis on the internal supply-side and, especially, on agglomeration effects.

Distance, and with it transportation and communications, are given somewhat different treatments in these models. In the demand driven framework, issues of market access are important, whereas in the supply driven approach congestion and impedances within cities that affect efficient production come far more to the fore.

There are variants on these models but none offers a conclusive explanation of why some cities grow faster and larger than others. Perhaps we should not be too surprised at this. Economists are poor at explaining economic growth more generally at the national level where the systems are less open. But there are also institutional factors involved. Cities do not operate in perfect markets, and neither does transportation and telecommunications systems, which means that a large element in the distribution of city sizes is inevitably due to government policies.

Rural areas matters

While there has been an increase in urbanization in virtually all countries, this still leaves a significant number of people who live and work in rural areas. The modern economics of agriculture, despite almost universal subsidies in the wealthy nations, has led to considerable

increases in labor productivity and with this a shedding of workers, indeed in France only about 3.5% of the workforce is in agriculture. The growth of service industries that are relatively footloose, coupled with the extensive networks of retail, entertainment, medical, and other essential services that can be accessed by telecommunications has, in part, softened this blow to the labor force (Clark, 1981; Clark and Unwin, 1981).

This decline in the traditional rural population, however, does not mean that the rural lifestyle, in a somewhat modified form, has entirely lost its attraction. There are many who are now choosing to move to the countryside to live. Many of these are retired people who seek the pure peace and quite of a less hectic life, but who can still retain contact with many of the attributes of urban life through telecommunication. Suburbs, of course, can provide a sort of ‘Neverland’ combining the features of rural and urban lifestyles.

Others live, and pursue their careers, in rural areas; albeit not in the traditional types of job found in such places. They make use of telecommunications to tie in with information systems and with their employers. Many of those living this way are from the creative classes, engaged in a variety of professions that require less immediate interaction with other parts of companies, or they work on a freelance basis.

There are some who argue that the ubiquitous nature of telecommunications will ultimately dominate the economies of agglomeration that have been the backbone of recent urbanization processes. There will be no particular advantage of living close to others. This will eventually lead to the demise of urban life-styles; there will be a *Death of Distance*, to cite the name of a well-known book (Caircross, 1997). The link between work and leisure, whereby ‘going to

work' entails pleasurable social interactions as well as economically productive activities, will break down and work will be done independently of any particular location. Globally, firms will locate at the lowest cost centers, be dispersed, and will be able to avoid the high cost/high taxation areas.

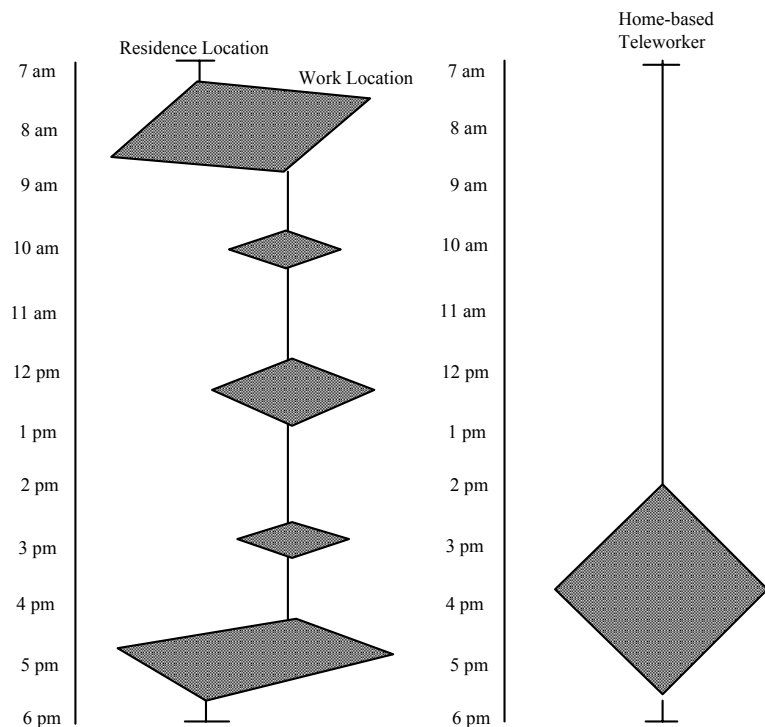
Such trends are, however, are likely to be very long-term if they are a genuine change in human behavior, rather than a transient phase, and far from simple to extrapolate (Kolko, 1999). There are many stranded costs to be considered if cities really were to be abandoned. If this were to take place then the pattern of human settlement would effectively revert back to that of older rural society with the difference that there would be no real link to land quality in the traditional way. Indeed, many areas that are not the best for farming (e.g., mountains, coasts, and arid areas) may be the most attractive. But this is a more a matter for futurists and sociologists than for speculation here.

THE SPACE–TIME PRISM

While it is quite easy to trace out the changing pattern of land-use, at least in its general form, more comprehensive theories offering explanations linking travel time, telecommunications, and land-use are less readily available. The notion of the 'space–time prism' and activity patterns developed by Hagerstrand (1970) provides one useful basis for looking at urban development. Black (2001), in particular, has used the methodology in this regard. The basic idea is essentially

a development of the longstanding economic model that increased choice enhances utility. In this case, as one gains flexibility due to more flexible working practices so the area of a person's space time prism expands.

Figure 3.4(a) provides a diagrammatic representation of a fairly standard space–time prism for a conventional working day. A commuter has some flexibility in the journey to work (which starts here at 7.15 am to ensure arrival by about 8.15 am), some time is also free during the lunch break to leave the office to do minor tasks, and on the way home after work that finishes at 4.30 pm. Coffee breaks may also add some flexible small space time increments but it is unclear how useful these are. The space–time prisms are dislocated somewhat to reflect the movements in space and the fact that there is a particular beginning and location at the start and the end of the day.



(b)

Figure 3.4 The space–time prism concept.

Black looks at what may happen if rather than commuting to an office, the worker teleworked from home. This would give the person more control over the time used in commuting, coffee breaks, and a lunch break. He assumes, however, that the constraints of beginning (at 7.15 am) and ending the working day (at 6.00 pm) at home still apply.

Figure 3.4(b) shows a possible resultant pattern. The worker could construct his day in a number of ways, but at the extreme there is nothing to stop the worker collecting various blocks

of time 'saved' and then using them all at once. For example, the worker could start work at 7.00 am and work straight through until 2.00 pm, and then spend the remaining four hours driving around. Whether this will happen is conjecture, but it is one possibility and has implications for urban form as it does for the more immediate case of traffic management.

Certainly, there would seem to be a strong case that telework could well lead to more travel if there are economies of scale and scope to be enjoyed from having larger blocks of discretionary time available. Indeed, one finds this even with the introduction of 'flexi-time', itself often facilitated by the advent of new communications within the conventional workplace, that has fostered more complex commuter trips as individuals make use of the freedom to add activities (shopping and collecting children from school are the most common in the US) to a formerly linear commute.

For land-use patterns the ability and willingness of individuals to act more flexibly within their new space-time prisms influences the need for the micro-location of activities, and also the way these activities are supplied. Economies of scale in supplying educational services for small children, for example, may be affected by the greater flexibility parents have in their dropping-off and collection times. Similarly, retail outlets can disperse more as the conventional radial routes no longer dominate commuter trips. This does, however, pose problems for those planning transportation infrastructure. The demands on transportation networks will inevitably be both temporally and spatially different.

THE 'NEW GEOGRAPHY'

The latter part of the twentieth century and the early part of the twenty-first have seen a renewed interest in things spatial. This has been tied to the availability of new data sources, with the development of GIS, which have resulted in an almost inevitable output of more informed empirical analysis. Globalization has led to interests be stimulated with regard to more macro issues as policy debates about its significance and consequences have taken place. These and other developments have had their effects across a range of academic disciplines as people have sought to understand change. The result has produced diverse views as one might expect in a still evolving situation.

The 'New Information Age Society' is largely immersed in the dynamic world of communication. One could argue at one level that the increasing proportion of complex goods produced and services provided in the modern economy has led to a greater proclivity toward human and company interaction. Advanced telecommunication systems are rapidly evolving to fill niche markets, enhancing efficiency of business and personal life through flexibility and timely information flow, as well as offering a range of generic services. Penetration of Internet connections into workplaces and households, as observed in western economies, has allowed consumers to browse and search for services and products, communicate between 'desktops', and, on average, access apposite information in a more timely manner than ever before. This may be thought of as a mechanism favoring neo-classical mechanisms for spatial convergence of economic performance.

Counter to this have been the ‘New Growth Theory’ arguments advanced by the likes of Robert Lucas (1990), Romer (1990) and others that the ‘New Information Age’ leads to the cumulative-and-circular divergence of economies. The regions or cities that have an initial advantage in information systems will enjoy a variety of internal and external benefits that will allow them to develop their advantages further. Their position has been supported by a body of empirical evidence, largely stemming from the new approaches to economic convergence measurement of Barro and Sala-i-Martin (1992), showing that regions are not converging significantly in their economic performance and certainly not in a way consistent with neo-classical analysis.

The economic argument for the decline in spatial variation, and indeed the potential end of cities, ties in closely with the degree to which electronic communications are substitutes for face-to-face contact (Gaspar and Glaeser, 1996). As we have seen the evidence on this is far from clear. Empirical analysis is constrained by data limitations and the difficulties of testing for causality over a short time period. There has been a tendency historically for urbanization to be unevenly spread, but often to broadly follow a consistent hierarchical pattern (Krugman, 1996).

Whether this pattern is sustainable in the context of the widespread use of the Internet is uncertain and even quite rigorous quantitative analysis has failed to produce a conclusive result.

The empirical work presented by Moss and Townsend (1998), for example, is very much in line with the larger ideas of Romer and Lucas and the more localized analysis of Krugman. There is a high correlation in the US between those urban areas that have a high concentration of information intensive functions, or of technology industries, and the concentration of deployment

of Internet technologies. They find a limited network of highly interconnected metropolitan areas that dominate the national network with economically distressed areas often being left behind.

Zook (2005), by exploring the geographical origins of domain names, also provides support for spatial concentration. Attempts to explore this situation using more sophisticated econometric analysis by Pelletiere and Rodrigo (1999), however, produced much less conclusive evidence.

This lack of any confirmation that the spread of Internet supply is in accord with the neoclassical convergence theory is also tending to be replicated in terms of physical distribution. The developments in information systems and e-commerce more generally have led, as outlined above, to a tendency to concentrate interchange and consolidation at a limited number of nodes. The focus of FedEx, the major carrier of e-commerce generated goods movements, in Memphis has been complemented by the city becoming a major trucking center and an important node in all the main railroad networks in the US. Geography has played a part in this but the information revolution has consolidated the hub-and-spoke nature of freight transportation.

These findings that largely refute neo-classical economics may not be that surprising, however, in light of the standard Vernon (1966) theory of product cycles. When new products emerge they tend to be located in regions with high quality labor and access to specialized information. Time erodes these needs as the product becomes more standardized. The Internet is too new to be able to ascertain whether it will follow this pattern or not. The situation at present is that economic and related theories abound linking the Internet and e-commerce to land-use developments, but the empirical support for any of them is still extremely tenuous.

CONCLUSIONS

It takes many years for the impacts of major technology shifts to be felt. The impact on urban form that the advent of railways brought about took time, many decades, to be felt and the concentric cities that followed were only partially formed when new forms of local public transport and then the motorcar emerged. Suburbia was a major result of the latter but this is still taking place some 80 years or so after the innovations of Henry Ford.

The 'Computer Age' was first talked about in the 1960s, but many of the impacts of the information technology that were foreseen are only really beginning to be felt in the first decade of the twenty-first century, and often in quite different forms. New technology and its use have to meet social needs as much as offering a more efficient way of doing existing activities. As Williamson indicated, there are some things that are embedded and not easily changed.

Many factors influence land-use patterns, some natural but others related to human involvement, deliberate or otherwise. Communications act both directly in influencing location patterns, and indirectly by influencing the use and form of the transportation systems. They can also act as a more general facilitator. But the effects can take considerable time to emerge as society physically repositions itself to exploit these technological changes and as the authorities reform the institutional structures that set the parameters in land markets.

At the global level, it is clear that many of the traditional economic notions of comparative advantage need at least to be modified as more mobile factors of production become important.

Information is certainly not ubiquitous and access to such things as broadband is far from space neutral – physically there are many places without it and elsewhere its costs vary quite significantly by location. Nevertheless, these factors can be acquired and consequently their acquisition will affect location patterns.

As a result, while globalization seems likely to continue, it will affect different parts of the world differently. Similarly, at the micro level some locations will remain more attractive for production and for living, but which they are, however, may well differ as a result of the telecommunications revolution. Perhaps the one lesson from the past is that predicting the implications of technology shifts on such slow moving things as land-use patterns is not to be taken lightly.

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