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TRAVEL, WORK, AND TELECOMMUNICATIONS: A VIEW OF THE ELECTRONICS REVOLUTION AND ITS POTENTIAL IMPACTS

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Abstract—Considerations of the impacts of electronic technologies on transportation usually focus on substitution of communications for travel, especially telecommuting. This topic is reviewed briefly, followed by consideration of electronic technology-induced changes in the structure of firms, work by individuals, and consumption. Today's organization of the work place on the basis of time-at-a-place measurements dates from early in the Industrial Revolution; the communications control of production dates from the introduction of the telegraph. Recent and upcoming communications developments may relax time and place requirements while intensifying communication control. Resulting changes in production and consumption may challenge transportation developments in coming decades.

INTRODUCTION

In considering the possible impacts of information technologies and other electronics innovations on transportation, many studies have focused on substitution effects and especially on opportunities for telecommunications to replace, or drastically reduce the length of, physical commuting to work (Nilles and Gray, 1975; Nilles et al., 1976; Harkness, 1977). This paper argues that transportation will be affected in much more fundamental ways than have been considered in the substitution literature. Electronic technologies are facilitating structural changes in production and consumption, which in turn may lead to basic reorientations in the nature of work and the use and location of work. These changes are likely to have profound economic and social effects which, while much larger than the transportation question, may necessitate rethinking the function of transport systems.

The paper begins with a review of the potential for substituting telecommunications for work travel. Then, looking at historical examples as well as to the future, the impacts of telecommunications and other electronic innovations on the function and organization of firms are examined. Next, the time and place effects of electronics innovations on work and transportation are explored. Finally, implications of these changes are considered.

TELECOMMUNICATIONS AND REDUCTIONS IN WORK TRAVEL: THE POTENTIAL FOR SUBSTITUTION

Congestion and the journey to (and from) work occurs, in part, because individuals must be at proximate work places at about the same time. In a traffic jam one dreams of telecommuting, the substitution of communications for travel to and from work. Highway managers also dream of telecommuting; they see it as a way of relieving traffic problems without costly and potentially disruptive capacity expansions. Environmentalists, energy specialists, and urbanists, too, dream of telecommuting, envisioning reduced auto emissions, lower energy consumption, and a general lessening of the impact of the auto on the city.

How well does this dreaming match realities? The evidence is that there is not much room for dreaming. First, only some jobs can be effectively done at home or at dispersed work stations. A hard look at the kinds of jobs for which telecommuting might be practicable suggests that the potential is limited. Telecommuting would work for those with very task-oriented jobs, where progress on tasks can be readily measured. It would further require, however, that personal supervision is unnecessary, that face-to-face interaction with others is unnecessary, and that the resources for completion of tasks can be available in the home or at workstations presumably closer to home than current work sites (DeSanctis, 1983).

For many people whose jobs match these characteristics, work at home already is technically feasible. Indeed, working away from the office or factory is hardly new—some industries have had a (not always honorable) tradition of home work, and office employees have long made their own work sites. The evening or occasionally stayed at home to finish a project without interruption or to handle a household need (Olson and Prims, 1984). For many of the latter group, new telecommunications devices are not required, only writing materials, documents to be processed, or a typewriter.

New telecommunications technologies may expand the number of people whose jobs could be performed at home or in remote sites, however. Terminals connected via phone lines and low-cost, high-powered computers are enabling programmers and systems analysts to do their work at home. Terminals and computers also may enable certain clerical and secretarial staff to work away from the main office, thus enabling close supervision and direction despite lack of proximity and by speeding the exchange of inputs, outputs, and instructions on what could be done by pickup and delivery systems plus the telephone. For example, telecommunications for measuring the number of keypunch made or transactions handled per unit time permit secretarial and clerical staff to be monitored without personal contact; electronic transfer of text and data permit exchange of materials without physical movement; e-mail systems allow communications to be relayed between distant locales. Indeed, all these technologies are being put to use, for example, by telephone companies who measure operator productivity electronically, airlines who centralize instruction the passenger regarding seat assignments, and credit card companies who use a single service center to handle customer inquiries from all over the country.

The work-at-home and dispersed workspace work options have been slow to take off, however, and there are several reasons for this. Managers have been one source of resistance; they have been reluctant to relinquish the control that personal supervision permits. They worry about getting a day's work for a day's pay, and fear that management by electronics is both impersonal and subject to manipulation by workers. Their salaries and status reflect the size of the operations they supervise, and the possibility that a smaller office or dispersed workforce would undermine their positions is unattractive. Potential benefits, including the possibilities for better worker morale and savings in office space, are uncertain and small compared to the potential disruptive effects of change. Managerial antagonisms to the work-at-home option are reflected in the sharp restrictions many managers place on employees permitted to do so; workers may be reclassified as hourly as opposed to regular employees, for example, and paid only for hours actually spent performing tasks, whereas in the office they would be paid whether or not there was a specific assignment to be performed (Olson, 1984; Olson and Prims, 1984).

Another source of resistance to telecommuting has been the employees themselves. Despite the presumption that in much of the telecommuting literature the work-at-home or dispersed workforce options would benefit employees, there is mounting evidence that many workers would not choose these options voluntarily. Some workers would clearly benefit: disabled people able to work but lacking mobility or needing inclusive support equipment, for example, and those whose home responsibilities would otherwise keep them out of the workforce. In addition, for workers whose skills are in high demand and whose work demands self-reliance, the work-at-home option may reinforce autonomy and positive feelings of self-control. For other workers, however, there are serious drawbacks, especially for the work-at-home option: its potential for interfering with in-home activities and usurping valuable household space, as well as the possibility that family responsibilities would interfere with work. Even at dispersed work sites, feelings of isolation and loss of opportunities for on-the-job learning, development of contacts, and reduced promotional opportunities are all problems that have been cited (Olson and Prims, 1984; Salomon, 1984; Salomon and Salomon, 1984).

The net result is that, although it has been estimated that many as 20% of all urban trips and as many as 50% of white-collar trips might technically be replaced by telecommuting (Tyler et al., 1976; Harkness, 1977), only 5%-10% of the workforce appears to be able and willing to substitute telecommuting for part or all of the commute (DeSanctis, 1983). Even the 10% figure would not be feasible without considerable effort in persuading firms to experiment with telecommunications.

Would such work at home or dispersed workstations reduce congestion? Ten percent of the work force is a lot of people, but that 10% does not translate easily into statements about traffic impacts (Jovanis, 1983). As much as half of the congestion on commute facilities depends on the facilities' vulnerability to disruption due to accidents or other incidents; not all congestion would be reduced by a reduction in demand. Furthermore, not all facilities from which telecommuting would remove trips are congested, and there is no a priori reason to assume that congested facilities would receive a proportionate share of the reduced demand. Indeed, where congestion is most severe, it is plausible that workers eligible for telecommuting have already pressed for options such as flex-time, or have otherwise removed themselves from the peak period. Moreover, many commuters have some choice over whether to travel at all and when they will travel. If, in turn, telecommuting results in fewer commutes for space facilities during the rush hours, some who are not now traveling during those hours might elect to do so. Overall, commuters might continue to congest facilities, even if a few are no longer traveling due to telecommuting.

Some benefits from increased telecommuting would surely be felt. With a hypothetical 10% telecommuting, here and there, workers might be freed from the daily round-trip to work. In some cases lowered demand might ease the problems transit properties have in serving the costly to serve journey to work. Where demand is low, perhaps the periods of congestion would be somewhat shorter.

Telecommuting as a substitute for commute travel thus appears to offer useful, though minor, possibilities for relieving peak-period traffic problems. It would be misleading to emphasize such possibilities, however, because the issue of telecommuting is swamped by larger ones. First, telecommuting is but one of many options; it uses only a couple of pieces from available электrотechnological building blocks—networks, computers, data storage and information systems, active and passive sensors, artificial intelligence and control methods, robotics, and...
It is too soon to say whether the technological formats that have already emerged will be the winning ones, or whether they will be pushed aside as more productive formats emerge. Nevertheless, we can already see changes in the organization of the workplace, and in the location of time and place requirements, as electronic innovations are introduced. It is to these changes, and their consequences, that we turn next.

TELECOMMUNICATIONS AND THE REORGANIZATION OF THE WORKPLACE

Much has been written on the use of electronics technologies in the reorganization of the workplace for labor and for other productivity improvements. Transportation industries, no less than other industries, provide examples of this. Transportation industries were quick to adopt computers, for example. Early on, the computer was used as a way to handle the paperwork involved in moving diverse shipments among diverse places and collecting tariffs. As the capabilities of the computer beyond substituting for clerical work were recognized, computers began to be used in inventory management, shipping tracking, and demand forecasting. Other electronics technologies, such as the telephone, and later televisions and telecopiers, have had an impact on the transportation industries including the use of sensors for detecting shifted loads, scanners for car control, robots for vehicle manufacturing, and so on.

The impact of telecommunications on corporate and workplace structure was felt much earlier, however, as is illustrated by the experience of early transportation firms. In England, for example, transportation firms in the late 19th and early 20th centuries had to provide for the provision of services and facilities and for the standardization of services and facilities to those services enlarged and as railroads were developed in the early 1800s. As organizations grew beyond the span of control that could be maintained, rules were established for the standardization of operations and were used to carry their work on.

The puzzle of a predominant technology was worked out in 1910s and 1920s. The Model-T and its mass production process, together with road paving, gave a first approximation of the emerging technological format. Uses of the automobile beyond social–recreational travel for the rich emerged in the 1920s along with the suburbanization of housing, shopping centers, and industries. The automobile revolution was off and running; auto–highway developments reorganized levels and patterns of production and consumption.

Like the examples of telecommunications and other electronics innovations pose the possibility of a technological revolution that will be the mother of changes yet to be understood (Garrison, 1970; Bennett, 1971). The answer to the question of what it is that we are putting building blocks together in exciting ways, and innovation after innovation is testing markets.
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transmit computer programs for metal bending, glass cutting, and window assembly, and schedule that work and the shipping of its product in light of the availability of machines and time when the building will be ready for window installation. Bauxite and silica come together and are processed just when needed and in the most cost-effective manner.

The emergence of a new principle for social organization will take time. After all, the evolution of time and place as the organizing principle for work took many decades and centuries. Some telecommunications developments pressing the organization of work (such as the telephone) have been with us for a while. It is going to take a while for some other things, such as advanced robotics and artificial intelligence, to come along, and there is a lot of innovative trial-and-error work to be done, with parallel social learning and change. Selling will surely be slow, because learning and unlearning takes time. Perhaps change will occur in individual phases as well as changes in the educational system and the ways in which individuals design their lives.

GONE FISHING?

What implications will changes in the organization of work, and in time and place requirements for work, have for society in general and for transportation in particular? Surely there will be major social problems to be solved as we go along: indeed, the electronics revolution may test society's ability to control its destiny.

On the downside, there is the potential for pervasive control of the many by the few, upsetting the delicate balance between those who govern and those who are governed. (See, e.g., Dasmunon, 1983.) Also, there is the question of rules. Decentralization of activities might well require complex rules, making it even more difficult for all to participate. For that matter, the increasing complexity of the technologies being utilized may exacerbate distinctions among people, where some participate effectively while others only follow along.

The matter of increasingly complex rules for effective participation is hidden because devices are increasingly "user friendly": it is easier and easier to use computers, for example. But to participate at other than a minimal level, one has to control computers and use them for one's purposes. It is one thing to access an information system according to fixed, albeit quite narrow, rules, and quite another to regard a file as a set of facts and devise rules to turn those facts into knowledge tailored to special needs. That skill is highly demanding.

On the up side, there is opportunity to be grasped. Today, actions are sharply disciplined by the clock and the watch, and by the locations of activities. Telecommunications and other electronics may relax that tyranny and grant new freedoms. Henry David Thoreau wrote, "Time is but the stream I go a-fishing in." Telecommunications and other electronics offer that freedom—the freedom for individuals to elect when, where, and how much they work and engage in other activities—by relaxing requirements for the synchronization of activities.

Conclusions about work and travel do not follow easily. Suppose work becomes more task-oriented and less time- and place-oriented. More task-organized work and less time- and place-oriented work suggests less frequent work trips. Those tasks based on spatially fixed resources, such as automated machines or farm fields, might be done with less frequent work journeys. As work locations become less dependent on labor sheds, new locations for work may be selected, with the journey to work more scattered than now and less amenable to efficient mass transit and highway service. At one extreme, one could imagine persons continuing to reside in the suburbs because of the amenities of urban life, but with the pattern of workplaces rather scattered and unrelated to the pattern of population. At the other extreme, most may opt for rural living, with both jobs and housing scattered.

Beyond the journey to work, there is travel for other purposes. Freedom to choose when to travel and how much to travel suggests a willingness to travel longer distances, and for longer periods of time, than is now possible. People have always been travelers. For example, fragmentary records from medieval times, such as the Canterbury Tales, suggest that extensive use of time for travel is inherent in development. Others find it old-fashioned, will we explore more? Given control of time schedules, one can arrange blocks of time in which to fish. Given today's transportation systems, one can fish in lots of places.

UNLOCKING CONSTRAINTS

We like to puzzle about the specifics, because it is fun—and sometimes frightening—to think about how things might be. But that thinking is limited by today's and yesterday's experiences, and our cognition ought to be scaled more generally. There is a need for rapid electrotechnology development and emerging options for social development—this is nothing new, for change and more change is our life experience as it was for our predecessors. At issue is managing that change in our interest.

At the transportation level, it is important to recognize that systems built for a society with time and place as organizing principles may not suit a society with other organizing principles. That is, the roles of telecommunications. Indeed, lack of flexibility of the transportation system may limit achievement of the social advantages of telecommunications. And questions of that sort ought to be on the minds of individuals, professionals, and policy makers in many desirable futures.

Whether there is more or less travel, travel will
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be different. Whatever the meaning of the electronic revolution, its meaning is more than substitution of communications for commuting or interregional travel. The transportation manager's question should be how transportation should be shaped to support a telecommunications society rather than how telecommuting might ease traffic problems.

REFERENCES


AGGLOMERATION DIECONOMIES OF TRAFFIC CONGESTION AND AGGLOMERATION ECONOMIES OF INTERACTION IN THE INFORMATION-ORIENTED CITY

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ABSTRACT: This paper presents a partial equilibrium model of land, labor, and transportation markets in an information-oriented city with traffic congestion of commuting and agglomeration economies of interaction. We derive the equilibrium by numerical computations using specific utility, production, and congestion functions. The laissez-faire equilibrium is compared with the optimum. In contrast with the results of many previous papers, the optimum is characterized by the CBD becomes compact and the city more suburbanized than the laissez-faire equilibrium. We also analyze the effects of a Pigouvian tax system and subsidies on the spatial structure in the city.

1. INTRODUCTION

A concentration of people and economic activity in a large city has both agglomeration economies and diseconomies. The size of the city is determined by the trade-off between those effects. Most previous papers on urban structure consider that the interaction among firms in the central business district (CBD) will generate agglomeration economies in production, and have analyzed the configuration of firm location. On the other hand, the agglomeration diseconomies of traffic congestion in the commuting rush hour are an important phenomenon to be analyzed in the new urban economics.

The spatial effects of congestion externalities were analyzed in previous studies (e.g., Strotz, 1975; Solow and Vickrey, 1971; Mills and de Ferranti, 1971; Sheshinski, 1973; Livesey, 1973; Oron, Pines, and Sheshinski, 1973; Dixit, 1973; Kanemoto, 1980; Sullivan, 1983). These studies derived the market equilibrium and the optimum equilibrium. It was shown that the optimum city is less suburbanized than the market equilibrium. The optimal land assignment for transportation in the city was also derived. In these papers, the decision on the allocation of land for transportation is based on a cost-benefit criterion using

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