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 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. Telecommunications 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 structure of transportation. 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 transportation 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 electronics 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 along 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 people with very task-oriented jobs, where progress on tasks can be readily measured. It would 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 workplaces (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 brought work home with them. 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 at 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, responsible tasks to be done at home.

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The net result is that, although it has been estimated that as 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 at 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 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 to telecommute 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 the future, telecommuting results in fewer commutes for space on 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, particular tasks or routings would be avoided. In some cases lowered demand might ease the problems transit properties have in serving the costly to serve journey to work. Where latent 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 electrolytotechnological building blocks—networks, computers, data storage and input/output systems, active and passive sensors, artificial intelligence and control methods, robotics, and...
more. Together, these amount to a revolution in electronics, information technology, with more and more complex, opportunities than the telecommunication option can offer.

Second, technological revolutions do much more than substitute for other production methods. Just as substitution itself may be more important as an enabling wedge for technological change than as a direct benefit. Substitution niches tell the innovator promising directions for development, and market responses reward successful innovators. As markets permit producers and consumers to learn to do new things in new ways, reorganization occurs and yields changed patterns of production, consumption, socialization, and political organization. New combinations of culture and social rules are pushed and bent.

Experience with the automobile in the early years of this century illustrates how technology substitution as the result of technological evolution, revolution that is not easy to predict. The building blocks for the automobile–highway system evolved over a long period of time, beginning with early roads. The idea of putting an engine on a wagon was around for a long time, at least from Reid's steam wagon, whose patent George Washington issued. The innovation pot was bubbling handily at the turn of the century, with Otto-cycle, steam, and electric propulsion on a wagon or buggy chassis competing for attention. Two puzzles had to be solved. What would the automobile be like in society, and of the myriad technological forms being promoted, what would predominant technology be like? Those puzzles did not solve easily.

In the early 1910s automobile could be substituted for the horse and buggy or the train for social and recreational travel, but only by the rich. The "rich folks' toy" stigma was so great that President Woodrow Wilson cautioned Princeton undergraduates about ostentatious consumption. From a social standpoint, the most that was hoped for were modest reductions in manure on city streets and of farmland near the cities. The puzzle of a predominant technology was worked out in the 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 industry. The automobile revolution was off and running; auto–highway developments reorganized levels and patterns of production and consumption.

Like transportation and 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; Be- mer, 1971). Whole new industries and organizations are putting building blocks together in exciting ways, and innovation after innovation is testing markets.

It is too soon to say whether the technological formats that have already emerged will be long living ones, or whether they will be pushed aside as more productive formats emerge. Nevertheless, we can already see changes in the organization of the work place, and in the location of place and time 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 internal labor market, 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, shipment tracking, and demand forecasting. Other electronic technologies, like the advent of the electronic telephone in the late 19th century, with Otto-cycle, steam, and electric propulsion on a wagon or buggy chassis competing for attention. Two puzzles had to be solved. What would the automobile be like in society, and of the myriad technological forms being promoted, what would predominant technology be like? Those puzzles did not solve easily.

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began to have clocks that could be hand-carried or kept in homes. The day was organized by hours, and there was also a weekly and a yearly calendar. The 200 church or lay holidays were first celebrated and then added to a weekly and yearly schedule.

The time frame of these clocks permitted a new urgency to the Industrial Revolution, which demanded the synchronization of labor at places other than home. The work place also required discipline to one's work in tandem with the work of others. An early instrument for this was the rule book, discussed earlier. Today, there are elaborate rules governing organization—manuals of practice or the equivalent. In organizations where it is critical that employee actions be predictable, the rules are explicit; the military, airlines, and hospitals are examples. The rules are not so obvious elsewhere, but they are there none the less.

Most people take rules for granted because another instrument was developed to condition the citizen into a synchromat. This is the public school system. Neither the Jeffersonian ideal nor the classical university was its motivator. Today, as yesterday, children are taught in school to do things at particular times and to follow instructions. Schoolroom socialization equips the child to do things according to today's organizing principles.

Transportation and communications had much to do with this time and place organization of life. The development of transportation enabled the large-scale movement of raw materials and finished products, the building of large urban centers, and the accessibility of work sites to large pools of labor. Communications supported the operation of transportation systems and networks of producing and consuming places.

Now, there is the revolution in electronics. Perhaps that revolution will continue in two ways. Some changes will enable what is done to be done much better, perhaps an order of magnitude better, and such a result could further lock today's patterns into place. Teleports are an example; they are being located in places far from their expected location, and the efficiency they offer (as well as the sheer size of the investment they require) may work against future changes. As another example, automatic switching systems, sensors, much improved data base management and inventory control facilities, and developments in other areas offer great potential for improving the productivity of transportation systems and the articulation of production and consumption processes. These changes, too, may tend to lock current patterns into place: when performance is good and improving, demands for new ways of doing things tend to be muted.

At the same time, electronics innovations may change the need to do things the way we do them now, creating possibilities for radical changes. These changes could result from relaxation of requirements for the time and place synchronization of labor. Emerging information systems, computer networking, communications devices, and other tools provide capabilities we have yet to understand well, but they appear to be permitting work to be done in new ways that demand less in the way of synchronized labor inputs.

How might telecommunications relax the requirements for the synchronization of labor? Driven by a desire to control and to live in a way that is convenient, we have learned to manage with assistants who are telephoning the telephone, afternoon and weekend answering services, and beepers. Innovations reduce the costs of such services and make them more affordable and flexible to many more. Indeed, the telephone answering machine, computer conferencing and message systems, and the cordless telephone have already relaxed time and place requirements for many communications.

In many service activities today, one must be at a specific place in order to obtain needed information; the information may be in books or files, available only through communication with a human. This is not the case of a particular computer. Computer information systems coupled with the rapid and inexpensive transmission of information may free such place requirements. Bibliographic searches are commonly conducted via computer; in some disciplines (e.g., law) the sources themselves can be accessed electronically. The telephone has long permitted access to people in remote locations, but computer message systems are relaxing time as well as place constraints, and electronic video transmission may further expand the kinds of information that can be effectively communicated in this manner. Further, electronic communications may even reduce the requirement for time, along with time and place constraints. Computer networking is permitting data transmission and sharing from numerous sites, and its use will surely grow as methods to prevent unauthorized access or interception are improved.

Other electronics advances may also free time and place requirements. Sensors may tell the farmer the state of crops in remote fields, and the efficiency they offer (as well as the sheer size of the investment they require) may work against future changes. As another example, automatic switching systems, sensors, much improved data base management and inventory control facilities, and developments in other areas offer great potential for improving the productivity of transportation systems and the articulation of production and consumption processes. These changes, too, may tend to lock current patterns into place: when performance is good and improving, demands for new ways of doing things tend to be muted.

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AGGLOMERATION DISECONOMIES 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, at the optimum 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...