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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 communications 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 framework. Electrotechnologies 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 organization of time. 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 on 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 could 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 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 worksites (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 in the evening or occasionally stayed at home to finish a project without interruption or to handle a household need (Olson and Primps, 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,

both by enabling close supervision and direction despite lack of proximity and by speeding the exchange of inputs, outputs, and instructions over what could be done by pickup and delivery systems plus the telephone. For example, technologies for measuring the number of keystrokes 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; message systems allow instructions 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 at one location the paging relays for all airports nationwide, 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 worksite 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 own salaries and status reflect the size of the operations they supervise, and the possibility that a smaller in-office 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 those employees permitted to do so; workers may be reclassified as hourly rather than 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, 1983; Olson and Primps, 1984).

Another source of resistance to telecommuting has been the employees themselves. Despite the presumption in much of the telecommuting literature that the work-at-home or dispersed worksite 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 extensive 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 worksites, 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 Primps, 1984; Salomon, 1984; Salomon and Salomon, 1984).

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 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 the short term, telecommuting results in fewer competing 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 work centers or routes might be advantaged. 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 electrotechnological building blocks—networks, computers, data storage and information systems, active and passive sensors, artificial intelligence and control methods, robotics, and more. Together, these amount to a revolution in electronics know-how, with many more, and more complex, opportunities than the telecommuting option can offer.

Second, technological revolutions do much more than substitute the new for the old. Substitution itself may be more important as an entering 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. The frames of culture and social rules are pushed and bent.

Experience with the automobile in the early years of this century illustrates how technology substitution can serve as the opening for technological revolution, 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, too, at least from Reid's steam wagon, whose patent George Washington issued. The innovation pot was bubbling handily at the beginning of the twentieth 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–highway system do for society, and of the myriad technological forms being promoted, what would predominant technology be like? Those puzzles did not solve easily.

In the early days, the 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 societal standpoint, the most that was hoped for were modest reductions of manure on city streets and of farmland needed to produce feed for animals.

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 the automobile, 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; Bemer, 1971). Innovative individuals 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 lasting 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 loosening of place and time requirements, as electronics 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 workplace, both as substitutes 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 electrotechnological innovations that have had major impact on the transportation industries include 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 facilities of the late 1700s—toll roads, canals, parish roads, and tramways—were provided by local organizations, and operators controlled one or at most a handful of vehicles. The geographical span for provision of facilities and for operations extended as those facilities were enlarged and as railroads were deployed in the early 1800s. As organizations grew beyond the span of personal control of managers, rules for the standardization of operations were increasingly used. Some of these rules were borrowed from potteries and textile mills (the extensive rule books used by today's railroads, for example, may be traced through the 1825 Stockton–Darlington Railroad to the potteries); others were developed in early transportation organizations themselves. In each case, however, the rules were designed to increase the predictability of actions, and adherence was assured by extensive rule books and training of workers to follow them.

Following the English example, rule books were quickly introduced for the U.S. railroads. But as the size of the new organizations tested managerial capabilities even with rules, other organizational changes soon followed. The functionally departmentalized structure of modern organizations is generally credited to McLane and Latrobe of the B&O

Railroad, who introduced it as a way of improving the control of finances, way, equipment, and operations.

The B&O's organizational structure was soon emulated by others, and refinements were introduced. Of particular importance were the procedures added by McCallum of the Erie Railroad to permit operational adjustments to reduce bottlenecks as well as to improve the costing of work and rate setting. By 1854, McCallum had begun to use telegraph telecommunications to fully monitor train operations and other aspects of the work of the firm. Train status was monitored on an hourly basis, and information was also transmitted to headquarters daily to allow the monitoring of expenditures, work performed by men and machines, and movements of passengers and freight. This data base allowed headquarters to exercise operating authority to modify rule-based behavior, as well as to carry out financial planning and to develop changes in the rules themselves.

The telegraph did not make rule books obsolete; rather, it established a superior level of control on those occasions when it was desirable to modify rule-based operations. With time, train orders transmitted by telegraph came into common use as a way of fine-tuning other operation rules, and the telegraph increased efficiency by permitting a layer of centralized control.

J. Edgar Thompson of the Pennsylvania Railroad decentralized the Erie scheme in 1857 by creating divisions, delegating control of labor and equipment to them, and concentrating headquarters activities on planning and financial matters. Thus was born the modern corporate staff-and-line structure, which eventually extended to other transportation modes and industry in general (Chandler and Salsbury, 1965).

Today, telecommunications and other electronics innovations are again restructuring corporations. Ayres and Steger (1985) point out that robotics, CAM, just-in-time inventory systems, and related innovations are enabling production on a smaller scale and at much lower cost than before, permitting greater specialization of goods and services to markets. With this product specialization are coming changes in the organization of the firm as well: for example, the increased importance of information about customers' needs and responsiveness to them calls for more links between the consumer and producer. Malone *et al.* (1987) argue that the impact of electronic connections within and between organizations will be felt in three ways: by allowing some firms to establish tighter connections with their suppliers or customers (internal and external to the firm) using electronic hierarchies; by supporting the creation of new "electronic markets" providing information on available suppliers or customers; and by permitting activities currently performed internally to be performed less expensively or more flexibly by outside suppliers whose selection and work could be coordinated by information technologies. They further argue that market forces will make it likely that unbiased markets will replace both biased markets (those favoring specific firms) and internal hierarchies, at least for products that are easily described and potentially available from a variety of sources. Bennett (1987) echoes this last point, claiming that the just-in-time concepts made possible by computerized inventory control and work scheduling are being applied to people as well as other inputs; firms no longer have to internalize people resources, but can buy people products as needed.

How might these changes in workplace organization and employment affect transportation requirements? Just as new methods of production are placing increased requirements for flexibility, responsiveness, and reliability on freight transportation, new organizational structures relying more heavily on information brokers and markets than internal hierarchies suggest more, but smaller, organizations, connected by contracts and communications rather than ownership and proximity. If this scenario proves accurate, everything from the structure of office and industrial buildings (less floor space needed per firm, for example) to its locational requirements (less need for centralized location, or for concentration, for that matter) may change. Such changes, in turn, would have far-reaching implications for transportation. The physical patterning of work trips could become more dispersed; the choice of mode could shift (less concentration and smaller firm size would work against transit and ridesharing, for example); the frequency of work travel could decline (as-needed employees might not work five days a week, or might work at different firms on different days). Other types of travel, such as midday shopping and business trips, and recreational and social journeys, could be altered as well. The implications of such scenarios for change have yet to be considered systematically.

TELECOMMUNICATIONS AND THE RELAXATION OF TIME AND PLACE REQUIREMENTS

In addition to confronting the organization of work, today's telecommunications and electronics innovations confront the time and place organization of society, an organization that in Western nations is rooted in changes that occurred from the 1400s to the present century. During this period, life was reorganized by two major technological developments. One was the clock and the work day and week, and the other was industrialization. Their result has been the time and place synchronization of activities, especially work.

In the Middle Ages, most people lived on the land and organized their lives according to the length of daylight, the rhythms of the seasons and crops, and church and lay holidays. Work and exchange for work were task-oriented. A time consciousness of another kind began to emerge as clocks were mounted in church and town hall steeples and as individuals began to have clocks that could be hand-carried or kept in homes. The day was organized by hours, and there was also reorganization of the week and the year. The 200+ church or lay holidays were first squeezed and reordered into a work week with Sunday and Monday holidays, then reordered with no holidays on Monday (and sometimes a half-holiday on Saturday), and finally ordered to the pattern as we know it now. By the 1600s clocks were commonplace in the towns and available in many homes; a century later, time was firmly associated with work, as illustrated by Ben Franklin's insight, "Time is money" (Thrift, 1981; Buckley, 1967).

The time consciousness that clocks permitted was a necessary precursor to the Industrial Revolution, which demanded the synchronization of labor at places. The synchronization of labor at the workplace also required diligence 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 rule books guiding most organizations—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 visible elsewhere, but they are there nonetheless.

Most people take rules for granted because another instrument was developed to condition the citizenry to the synchronization of tasks: 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 operations 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 now 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 to enhance existing activities, 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, 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 organized in new ways that demand less in the way of synchronized labor inputs.

How might telecommunications relax the requirement for the synchronization of labor? Driven by inability to control their schedules, medical doctors learned to manage with assistants manning the telephones, evening and weekend answering services, and beepers. Innovations reducing the costs of such services and improving them may open scheduling flexibility 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 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 support staff, or accessible only on a particular computer. Computer information systems coupled with capabilities for the rapid and inexpensive transmission of information may free such place requirements. Already, 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 from 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. Expert systems may even reduce the people requirement, 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 also may free time and place requirements. Sensors may tell the farmer the state of crops in remote fields, reducing the need for inspections at specific times and places. Many products are manufactured by processing here, transporting there for additional processing, and so on. Better information systems could simplify the time and place scheduling of these activities. As robots are improved and skills transferred from workers to robots, applications of processing skills might be scheduled as desired and where desired. The architect, for example, might custom design windows,

transmit computer programs for metal bending, glass cutting, and window assembly, and schedule that work and the shipment 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: some change and some embedding.

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 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. Change will surely be slow, because learning and unlearning takes time. Perhaps change will occur with intergenerational 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 some 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 down side, 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. *Datamation*, 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 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-oriented 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 live in or near cities 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 more miles of travel might be involved. People seem to have always been travellers. For example, fragmentary records from medieval times, such as *The Canterbury Tales*, suggest that extensive use of time for travel is hardly a new development. Freed from time constraints, 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 are rapid electrotechnology developments 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 a larger matter than telecommuting. 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 arenas, because "business as usual" may constrain desirable futures.

Whether there is more or less travel, travel will be different. Whatever the meaning of the electronics 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.

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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 equilibria 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 equilibriun and the optimum equilibrium. It was shown that the optimum city is les suburbanized than the market equilibrium. The optimal land assignment fo transportation in the city was also derived. In these papers, the decision on th allocation of land for transportation is based on a cost-benefit criterion usin

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