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Information Technology :

Implications for Transportation

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Summary

Electronics and telecommunications are rapidly changing and are having significant impacts on social and economic activity, with major implications for transportation. Location of businesses and households may be altered as telecommunications options improve. Already, there is evidence that businesses have become less dependent on proximate locations as electronic links have become more effective alternatives to face-to-face communications. And while full-time telecommuting is relatively rare today, telecommunications systems do appear to enable many workers to "commute" from a home office on a part-time basis.

In an era when major physical infrastructure projects are increasingly hard to complete and yet travel demands have never been greater, information technology offers great promise in enhancing existing capacity with relatively minor adjustments to existing physical infrastructure. In implementing information technology, however, it is important to appreciate the political context. Seemingly ironic, learning from failure and improving on mistakes is actually crucial in technological innovation and progress.

Introduction

The claim that informational technology is changing the way we live and work in cities is commonplace and increasingly accepted, but what exactly these changes might be and how they actually come about is not as well thought-out. The transformations are fundamental for the transportation system, long a leading factor in urban change. The implications of information technology upon transportation patterns must be properly understood, and the social and organizational process of how to best integrate information technology into transportation operations is essential, yet largely underinvestigated.

Information technology is simultaneously increasing the demand for travel and mobility; yet interestingly, it also offers the ability to facilitate these same increases in travel. Its implementation should not be approached as "one-size-fits-all". Its successful integration requires knowledge of how technologies are actually used by individuals and groups and how innovation actually comes about.

Drawing upon the literature on the topic, this paper discusses the increased demand for travel and the telecommunications–transportation relationship; the difficulty of getting large-scale infrastructure built and the possibility of using information technology as an alternative, and lessons for successful implementation.

The Increasing Demand to Travel: The Telecommications – Transportation Relationship

It is well understood that most travel is a derived demand; people travel not for the sake of movement, but because they have a reason to be somewhere. Likewise, goods movement also has clear purpose. Information technology -- a broad term for any system used to communicate information: telegraphy, telephony, replication technologies, the Internet -- stimulates and feeds these needs to be somewhere, and physical contact, in turn, often stimulates the need for more information exchanges. This reflexive relationship between communications and transportation is long-standing, although it has not always been recognized

The relationship between individual transportation trips and individual telecommunications connections is complex, but we do have a basic understanding of the relationship. While as recently as the 1970s it was commonly thought that telecommunications improvements could substitute for physical travel and thus perhaps be environmentally beneficial, it is increasingly recognized that telecommunications activity and physical transportation movements are *complements* to each other rather than *substitutes* in the aggregate. (Gould and Golob, 1998; Graham and Marvin, 1996; Niles, 1991, 1994; Plaut, 1997) A telecommunications link may substitute for what was once a physical trip, but the telecommunications activity actually generates further *new* trips, stimulating more travel, not less. Historically, this was demonstrated with the simultaneous extension of telegraph and railroad networks in the nineteenth century. A telegraph link would reduce the need for certain types of travel, but the relative ease of communication provided by the telegraph expanded business and personal networks and enhanced the efficiency of railroad shipping operations. While a person might not need to make certain trips due to better telecommunications, this increased 'tele-connection' also allows them to extend and deepen their personal and business networks, allowing a greater awareness of more opportunities and thus encouraging more travel.

This offers an important lesson for any travel reduction program. In the aggregate, the demand to travel and interact is highly unlikely to diminish in an increasingly networked society (Gillespie and Richardson, 1999), so reducing the environmental impacts of such travel is critical. The goal should be to allow people to travel in more environmentally benign forms of movement, not to limit the ability for people to interact. This also implies profound possibilities for the organization of land uses. If people can meet their interaction needs over shorter distances and closer proximities, a genuine 'network effect' can be realized with a minimal ecological burden. Travel distances are reduced, but the increased travel (interaction) demands have been met.

Telecommunications improvements also seem to enhance the flexibility of work and time in general, reflecting an accompanying boom in leisure and 'off-peak' travel. Given that the urban transportation professions have historically been geared to handle work-commute trips, there is a relatively poorer understanding of leisure and off-peak travel, yet such travel makes up as much as 80% of total trips (U.S. Department of Transportation, 1997).

Handling this increased travel demand is a daunting task, made even more difficult by the contemporary urban political climate. Just at a time when the demand for travel is dramatically increasing, however, the ability to build significant new physical infrastructure to handle increases in travel is impaired.

Increasing Obstacles to Large-Scale Development of Physical Infrastructure

Major transportation construction projects are more expensive than they were in the past. Higher costs reflect the introduction of vastly improved community safeguards and environmental protection and extensive safety features (including, in California, earthquake engineering). Costs also reflect the reality that many of today's projects must be built or rebuilt in developed areas or through environmentally and socially important properties (e.g., wetlands, unique farmlands), with the result that projects are both more complicated and more likely to be contested. The tremendous cost and time overruns of such recent major projects as the "Big Dig" in Boston and Denver International Airport attest tho the difficulties major infrastructure projects face. Environmental regulations, community politics, and disputes over the goals and financing of projects combine greatly complicate the implementation of major physical infrastructure. Even if these processes are somehow streamlined, the basic concerns remain, and the political climate has been irrevocably altered. Any threat of major disruption to a community's perceived environment is unlikely to go unchallenged. Indeed, information technology allows communities of opposition to major projects to be rapidly formed and mobilized.

In addition, there increasingly are pressing needs to maintain and repair *existing* infrastructure. Not only is much existing infrastructure in need of attention, it is frequently very costly to do the necessary work. Diverting traffic from crowded freeways and arterials is not always possible, because there literally are no alternative routes with sufficient capacity to handle the diversions. Shifting to night construction helps somewhat, but is more costly and more dangerous for both workers and drivers. Further, with many urban and suburban freeways and arterials carrying heavy traffic loads for 16-18 hours a day, even night work can disrupt traffic substantially. Thus maintaining the existing infrastructure has become a major expense, further limiting both funding availability and political will for new construction.

Information Technology as the Solution?

At a time when travel demand is burgeoning due to a society "networked" through information technologies, the ability to roll out new infrastructure is impaired; however, information technology actually offers some solutions to the very problem it is helping to generate. Information technology allows transportation systems to be "smart", whereby complex and vast amounts of data can be sensed and managed in a comprehensive or iterative manner. Movements can be tracked and monitored, and facilities can be better managed. Existing *in situ* infrastructure can handle new increased capacities through the appropriate use of information technology. The very "stealthiness" of information technology processes also allows it to escape a great deal of protest or criticism.

Information technology promises great improvements to transportation systems through the three principle organizational advantages it offers:

1) enhancing ease-of-use
2) inventory management
3) increasing flow capacity

1) Enhancing Ease-of-Use

Information technology can be used to make travel transactions easier and more convenient. Switching modes or utilizing different transport systems can be increasingly seamless, allowing for integrated multi-modal transport. Payment can come from a single source in the form of a "smart" card that can be detected by different devices. Tolls can be collected automatically, allowing for smooth, continuous movement. Other flexible payment schemes include parking meters and other fees being paid through cell phone accounts. Such systems are already operational in parts of Scandinavia.

One of the flaws of contemporary mass transit systems is the regular need to transfer and the annoyances involved with this process. With the "wireless" Internet, the technology exists for transit riders to monitor bus movements and to have reliable estimates of arrival times. This confidence of use would make transit more effective and likely more widely used. As will be discussed later, the central issue is actually reduced to one of implementation.

2) Inventory Management

Reservations management is the great capability triumph of information technology. The flexibility of information technology can be utilized to better manage inventories of people and vehicles. Reservations management can be applied to seat allocations, parking spaces, times of use: basically anything that can be scheduled. It should be no surprise that the airlines were pioneers in the utilization of information technology. Since the 1960s, information technology has radically transformed airline operations and allowed for significant efficiencies. The ability to reserve spaces remotely and in advance greatly enhances the "load factor" of the use of a facility. The continuous stream of data on availability and demand that can be provided through information technology allows for variable pricing schemes, allowing for more efficient utilizations. For example, at times of heavy demand, a reservation is quite expensive. At times of low demand, a reservation is inexpensive or free. Instantaneous, flexible pricing maximizes the inventory capacity of parking lots, buses, trains, etc., allowing consumers to make choices on the necessity of their use of the facility. Car-sharing programs, for instance, can be greatly enhanced through information technology, as the availability of certain vehicles can be quickly recognized.

3) Increasing Flow Capacity

Related to its capabilities in inventory management, information technology can also increase flow capacity with little additional physical infrastructure. Information technology is thus capable of enhancing capacities of transportation equipment and facilities with little or no new physical expansion. Examples of enhancing flow capacity with little additional physical infrastructure include Traffic Congestion Management (surveillance of congestion points), freeway ramp metering, and "smart" traffic signals. Vehicle capacities themselves could also increase significantly, as new innovative forms of transit or "jitneys" could have a renaissance in a "wired" world. Arranging shared rides may be easier than ever before in an era of mobile phones and the Internet. In their theoretical development, automated highways would also offer great capacity increases, although there are considerable obstacles in getting such projects implemented.

Beyond the Technology: Lessons for Successful Implementation

While information technology has some remarkable capabilities, the way new technologies are actually implemented is profoundly important, requiring the greatest consideration. It is not simply the development of a technology, but the *process* of how it is implemented and utilized. This tends to be a neglected area of research, especially compared to the development of the technology itself, yet it is critically important to transportation organizations. "Technology transfer" cannot simply be described mechanistically either. It involves how technology is appropriated, utilized, and *innovated upon* within different social frameworks.

The older view of technological determinism declares that technological development is the driving force of history. It assumes that technological progress is inevitable and removed from politics. Technology drives society, and society can only adapt to it sooner or later. Innovation is supposedly linear and rational, yet actual studies of innovation processes put technological determinism into question. While technological determinism has yet to be satisfactorily disproved, it is increasingly challenged and disputed by scholarship on the nature of technology. (Marx and Smith, 1994)

A more contemporary and increasingly prevalent view of technology is the social construction of technology (SCOT) approach: technology is a part of society, not removed from society. Technology is not isolated as a mysterious "black box" but very much a integral product of society and human politics. It is created in response to social and political needs, and its effective implementation very much depends on the social and political context. It challenges the technological determinist assumptions of technology as benign, inevitable, and beyond human politics.

Accordingly, if we consider technology as a product of human society, it is thus very much subject to the process of politics. It has sometimes been assumed that new technology can overcome political problems, yet this is increasingly refuted. Technological innovation cannot adequately address problems that are primarily political in nature. Political problems require political solutions.

Examples of the social process of technology abound in the transportation field and reveal the importance of understanding the social and political processes of implementing appropriate technologies. One prime example is the decades-old, but largely fruitless, process of implementing congestion pricing. Many transportation experts agree that this would be a viable method to manage congestion, yet rarely has it ever been implemented. In democracies, the political will to implement congestion pricing is often lacking, despite what rational analysis touts about its benefits. While it is technologically feasible and even desirable in terms of efficiency, congestion pricing is politically unviable. The implementation of congestion pricing technology will not occur until the political and social obstacles are overcome.

Automated highways exemplify a technology that seems feasible in testing, yet is likely never to be implemented due to serious social and political constraints on the application of the technology. Since the automated system would be assuming the responsibility of the driver, the liability risk for any accidents through system failure is immense. An accidental blown tire or a piece of debris could be devastating to such a system. The necessary stringent safeguards to ensure system confidence would likely make the system prohibitively more expensive than its proposed benefits. In addition, if indeed every car needed to be outfitted with special radar and sensing-control equipment, this would be an enormous cost borne by the consumer and would raise particular equity considerations. Also, how automated highways can seamlessly be integrated into a non-automated street network is a considerable dilemma that has not been significantly addressed. This is not to say that individual technologies associated with automated highways will not eventually find useful applications, but despite what its proponents say, the grand system of automated highways is most unlikely to be ever implemented as imagined.

How then do we innovate to produce effective and efficient transportation technologies? Through studies of technological development and implementation, there have been important lessons in how innovation actually comes about, and they seem to defy common-sense notions. Most notably, trial-and-error is fundamentally important in innovation. In his argument on why Intelligent Transportation Systems should be 'small', Stein Weissenberger outlines three key points from studies of actual innovation:

1. Technological knowledge is acquired through "learning by doing" and "learning by using".
2. Technologies are most often developed *incrementally*, and inevitably through processes of making errors, and improving designs in an evolutionary fashion.
3. Learning networks are crucial to the development of complex new technology. (Weissenberger, 1999)

Innovations are not arrived at through a linear process. There is no obvious right way that can be determined in advance. It must be reached at through experimentation, trial-and-error, and social learning. Organizational networks that are iterative and adaptive are the most innovative.

A better understanding of these processes would save a great deal of money and resources. It is often difficult for large institutions to recognize that mistakes -- and the learning that comes from them -- are actually productive and even essential over the long term. Often mistakes are avoided at all costs, because there are political consequences for such mistakes. Organizational structures that allow for experimentation and trial-by-error as a normal part of their process are more likely to produce innovations and improvements than an organization that can do "no wrong". This may require a degree of shielding from political interference over immediate results to allow an iterative learning process.

Producing innovation is inherently risky, as failure is part of the process. In order to allow for vibrant innovative structures than can actually implement new "intelligent" transportation systems effectively, there should be a multitude of risky but small-budget projects rather than only a few large-budget projects. Large-budget projects are often not allowed to appear to "fail", as too much politcal and financial capital is invested in them. Smaller projects, however, can more easily be allowed to fail – as long as we can learn from them – precisely because they are small and several. A small project that proves innovative and successful can bring bountiful improvements and 'learning' to many other simultaneous projects. Indeed, this is the lesson of the vaunted Silicon Valley entrepreneurs. The vast majority of entrepreneurs who 'struck it rich' had failed in previous endeavors. The very fact that they had learned from their errors allowed them to arrive at better technologies and innovations. Remarkably, the "right to fail" seems a structural prerequisite for ultimate success.

Conclusions

Information technology offers great promise to transportation policy. On the one hand, it facilitates an economy that places great stresses on an existing transportation system that faces great difficulties in commensurate physical expansion; on the other hand, its inherent advantages also allows existing transportation infrastructure to become far more efficient. Studies of technological innovation and adoption, however, warn that social and political processes are just as important as the technology itself. Technological development is not considered to be linear, and innovative applications come through a process of trial-and-error and iterative learning, not a pre-determined plan of development. It is crucial that transportation organizations better understand the social and political dimension of applying technology. The recent rapid advances in information technology have profound implications for transportation studies, but their successful implementation into the transportation system ultimately hinges on social practice and organization.

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