

REPORT ON TRENDS AND CONDITIONS RESEARCH

THE IMPACT OF THE INTERNET ON TRANSPORTATION IN FLORIDA – CURRENT ECONOMIC PERSPECTIVE AND POSSIBILITIES FOR FURTHER RESEARCH

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FDOT CONTRACT NUMBER BC-354-44

MARCH 28, 2002

Revised June 10, 2002

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EXECUTIVE SUMMARY

The purpose of this paper is to survey current literature on the economic impact of the Internet on transportation. To that end we have searched literature across disciplines including sociology, geography, business, and economics that offers potential answers to the following questions:

- How are companies incorporating Internet technology into their products and business models?
- How will the Internet change commuter and shipping traffic? By how much?
- What models are available to predict the impact of the Internet on future transportation patterns?
- How does the Internet compare to previous innovations?
- How will national technological, transportation, and commuting trends affect Florida's economy and infrastructure?

In general, the current literature regarding the impact of the Internet is limited. Most recent publications focus on price theory, market expansion, and information economics, not urban economics. From a literature review across disciplines, however, we were able to uncover several related articles from which we draw inferences. The tentative conclusions that may be drawn from the literature are far from established empirical fact. However, most research does fit with the following conclusions.

- Businesses have adapted to the Internet both as a means of increasing profits via increased sales and streamlining costs by taking advantage of the technology. The Internet allows firms to rethink their business structure and location in order to take advantage of economies of scale. This may impact the composition of business travel demand, but not necessarily the volume.
- Telecommuting, first via telephone and now the Internet, serves as a complement rather than a substitute for commuting. Innovations in telecommunications may have affected the composition of commuting but not necessarily the volume.
- Cities have become less centralized for two centuries. Neither the effect of the Internet nor the telephone has spurred the decrease in concentration although they are facilitators. Network cities have formed as part of the dispersion process, perhaps changing the direction of diffusion, but probably not increasing the speed.
- Models for urban form have not come to grips with the effects of telecommunications advances on city structure, other than to say that as transportation costs (broadly defined to include the impacts of the Internet) decline and people become wealthier, the expected and welfare maximizing outcome is for cities to become more dispersed.
- Internet technologies, and information technologies generally, created growth in the 1990s. There is some debate about whether 1) the tech sector grew fast at that time

but did not spur faster growth in other sectors, or 2) diffusion of information technology lead to faster productivity growth across the entire economy. There appears to be an emerging consensus among macro-economists that the effect of the “new-economy” has been to boost productivity growth in a broad way, and that this might continue for some time as new ways of enhancing efficiency are developed. How much of this has been due to information technology, and how much has been due to other factors such as deregulation and increased ease of laying off low-productivity workers during downturns is an open question.

- On balance, claims that the Internet - or information technology more generally - will radically either increase or decrease demands on the transportation system to move goods and workers seem overblown, or at least unsubstantiated.
- Further study of national trends in this area, and perhaps time for creation of more data points, is needed before there can be many reliable predictions about the impact of the Internet on transportation needs in Florida, although a few studies relevant to Florida may now be possible.
- Florida is a peninsula state and a tourist destination. Therefore the finding that electronic vehicle management systems (EVMS) have increased capacity utilization in the trucking industry by 13 percent may have specific implications for transportation in Florida. Florida Department of Transportation (FDOT) might find a study verifying this finding for Florida and tracing out its implications to be useful.
- The possibility that information technology leads to dispersion through encouraging corridor cities more strongly than by encouraging dispersion of existing cities in all directions can be explored for potential corridor cities in Florida. Since the direction of future dispersion matters to transportation planning, FDOT might find this to be a useful study.
- It is possible at this time to survey employers in Florida to determine the level and trend of telecommuting and the perceptions of why it is or might be valuable to Florida’s workers and firms. This might lead to implications for overall transportation demand or indicate patterns of demand shift that have implications for transportation planning.
- It is through information technology based developments such as centralized traffic signal control and electronic toll collection that the Internet likely will have its most important impacts on transportation in Florida. Such developments will provide much more flexible and precise tools for FDOT to use in planning for and managing Florida’s traffic and infrastructure requirements.

1. INTRODUCTION

The economic expansion in the 1990s has led to widespread speculation regarding how much growth resulted from computer technologies like the Internet. While enthusiasm for the Internet has fallen since the stock market bubble burst, some analysts remain optimistic and believe that the Internet will revolutionize everything from how industries operate to how cities are built.

As Washington state's policymakers prepare to spend billions of dollars on re-engineering the state's crumbling transportation network, they should recognize that the forces building the knowledge economy and the Internet Age will alter the commuting patterns of Washingtonians for decades to come. Failure to comprehend these trends could result in a massive build-out of a transportation system predicated on Industrial Age assumptions. (Hughes and Nelson, 2002)

Others believe that while the advantages of the Internet are great, they are less than revolutionary. They believe businesses will change, but only because they will see new opportunities and adapt to them. “The logic behind many claims...tends to overlook the complexity of the city and is therefore too inclined to adopt a view of quite radical change” (Salomon, 1996).

The limited empirical work specifically on the subject has allowed the debate to continue among academics, businessmen, and politicians. Most work regarding the Internet is done with a perspective on price theory, market expansion, and information economics. However, parallels can be drawn between current and past technological innovations and thus analyzing the academic literature is useful. The purpose of this paper is to survey current literature on the economic impact of the Internet on transportation or draw parallels to similar research and identify areas where future empirical study is warranted.

DEFINITIONS AND SCOPE

Though the word “Internet” usually refers to the World Wide Web (Web), the term has a broader scope. Under the most technical definitions the Internet may be described as a connection of computers over a network. This includes the Web, email, Internet service providers, corporate intranets, and file servers. This paper uses the word Internet in the general sense, while components of the Internet are referred to by name (e.g., Web, email, intranet). Equally broad in scope, transportation is used in the context of commercial airlines, trucking, and consumer vehicles. Other transportation components, when referred to, are mentioned specifically.

We begin by exploring how companies in the transportation industry and local governments have incorporated Internet technologies into their products, services, and business methods. We also briefly consider the direct impact of information technology upon transportation planning and management. We then tackle the larger issue of transportation using the study of urban form. The following section describes the degree to which the Internet has impacted and will continue to impact economic growth. We end this paper with a brief set of conclusions that may be drawn from the academic literature and then a discussion of potential future research.

2. INDUSTRY, INFRASTRUCTURE, AND THE INTERNET

In this section we discuss how the Internet is being used by four major transportation components: commercial airlines, automobiles, commercial trucking, and public infrastructure. We then summarize general conclusions that can be made across all industries regarding the impact of the Internet. Information has been gathered from Standard & Poor's industry surveys, newspaper and magazine articles and industry trade associations. (Calculations and estimates, unless otherwise stated, are from Standard & Poor's industry surveys.) Little academic literature was available, and therefore does not make up a significant part of this section.

AIR TRAVEL INDUSTRY

The air travel industry historically has been a low-growth industry. Recently profits have grown merely at the same rate as the gross domestic product (GDP). Rising labor costs and susceptibility to oil price spikes have led the industry to seek out new low-cost ideas like those offered by Internet technologies.

Businesses from all industries began adopting (and adapting to) the Web in 1995, and the airline industry was no different. In the beginning, websites were used for promotional material, fleet description and flight schedules. As Web technology began to advance, so did the websites. Southwest Airlines began to book flights online in 1996, and now 20 percent of its bookings are taken over the Web. The cost savings for Southwest are estimated to be over \$5 per booking. Electronic tickets have also allowed airlines to reduce costs by reducing the amount of staff needed to process the ticket.

The effect of the Internet on air travel is not limited to airline companies. Online travel business-to-consumer (b-to-c) sites like Travelocity.com and Expedia.com were established in March and October of 1996, respectively. In 1999, four of the largest American companies established Orbitz.com in an effort to reduce total premiums paid to travel agents. Orbitz was launched in July 2001 after some scrutiny by the Department of Transportation (and a lawsuit by Southwest Airlines). Further investigations by the Department of Justice and Department of Transportation will come in 2002, but the presence of Internet technology will remain regardless of Orbitz's fate.

We note that while these effects are real, and important, they are likely to have little effect on the level of final demand for air travel. This is because these improvements are at work on only a small component of the overall cost of air travel. While they may encourage substitution away from travel agents to other forms of booking, they do little to reduce the cost of getting the plane in the air and to its destination. An exception is that better information flow and pricing responses may reduce costs per passenger-mile by boosting load factors. But in general, the demand for airline travel would have to be very elastic indeed for the effect on travel demand to be pronounced.

AUTOMOBILE INDUSTRY

Recent trends in the automobile sector echo the impact the Internet is having in other transportation related industries. Most automobile manufacturers depend on "just-in-time" inventories where parts are ordered when needed and hence keep inventory storage costs low. Similar to the airline industry, companies have embraced the Web as a place for consumers to collect information. Honda, Ford, and Chrysler brands all have interactive sites whereby consumers may pick and choose features, options, and see the suggested retail price given those choices. In addition,

Ford and Microsoft are working together on CarPoint, a car buying service; as part of the Microsoft's web portal msn.com. Speculation is that consumers will be able to have a car "made to order" after visiting the site. Car buying and selling on the Web was further enhanced when eBay, a Web auctioneer, began to offer cars and trucks on its site in 2000.

Internet-related impacts are not limited to how trucks and cars are marketed and sold, but also affect the options that are available. Computer and telecommunication service, including the Internet, in cars (known as telematics) increasingly is offered in vehicles. OnStar, provided through General Motors, provides services like directions, emergency assistance, and Internet access. DaimlerChrysler has announced that by 2003 every commercial truck, van and car will have in-vehicle voice services run on Bluetooth wireless technology. While consumers are spending more time on the Web to research purchases, there is no evidence that the new research has changed what consumers have purchased, that they have shifted preferences to more fuel-efficient or Internet-option laden autos.

Unlike the airline industry, automakers have established a business-to-business (b-to-b) network rather than b-to-c. Covisint was established to curb wasted resources between automakers and suppliers. The site offers supply-chain management tools and a means of purchasing inputs via auction or catalog. The long run success of the site, like all e-business, is subject to some speculation, but Ford claims to have recouped its initial investment in the b-to-b site. By establishing a profit-enhancing system on input costs, Covisint has thus far avoided the anti-trust problems Orbitz has gone through. However, the Federal Trade Commission is aware of potential problems in the business venture.

Clearly, these changes promote consumer welfare by offering more and better choices and improving the efficiency of shopping for automobiles. Yet, one person can drive only one car at a time, and further, has a fixed amount of time in which to drive. Therefore, the impact on transportation needs and planning here is likely to be small.

COMMERCIAL TRUCKING AND TRANSPORT

While the Internet increases the auto and airline industries' direct reach to consumers, online retailers or "e-tailers" rely on the commercial transportation sector for their goods to reach consumers. Rather than going to the store, many consumers are ordering goods online and having them shipped to their homes via common carriers like the U.S. Postal Service, United Parcel Service, or Federal Express. While calculations of the size of e-commerce volume are staggering, it is important to note that most estimates of e-commerce sales include financial services and electronic transfers. These types of purchases will not affect the transportation industry since they are digital transactions. Further caveats include the substitution of catalog sales by online sales. The degree of substitution is not known but it is clear that substituting a sweater bought from a catalog for one bought from an e-tailer will not change transportation volume but may change composition. The substitution from store purchases to online purchases will, however, have a huge impact on transportation-shifting the supply chain from middlemen to direct interaction between producers and consumers. Dell, an online computer company, is one example.

As in the auto industry, transmetics have made their way into the commercial trucking industry, not as gimmicks and options but as business tools. Linked to dispatchers through satellites, truckers are able to avoid traffic congestion and bad weather. Thomas Hubbard (2001) has found that electronic vehicle management systems have lead to more efficient resource allocations. EVMS computers record mileage, idle time, and geographic location, and connect the dispatcher and the driver in real time. The trucking dispatcher can schedule routes for existing orders more efficiently

and then market any additional trailer capacity to additional clients. Hubbard estimates that capacity utilization increased by 13 percent on average for companies adopting on-board computers. This comes about largely through decreasing the frequency of empty back-hauls. A non-business perk is that the on-board computers also allow truck drivers to communicate with their families, something that may lower the high driver turnover experienced in the industry.

These are real effects that do directly affect transportation demand, and therefore might impact what is needed from transportation planners. First, relative changes in prices could shift demand among final products. Depending upon the transportation intensity of the products that are shifted to or from, this could either increase or decrease transportation demand. Second, sending products more directly to consumers could change the nature of transportation needs. Third, increasing capacity utilization of trucking would seem to lower the need for transportation infrastructure. On the other hand, the increases in efficiency might stimulate demand for trucking. For example, it is not clear that all of the items carried on what used to be empty backhauls would have been shipped at all before the Internet. There is no evidence, or even sound reason to suspect, at least at this point, that the Internet will bring about either large increases or decreases in demand for transportation.

INDUSTRY SUMMARY

In spite of the penetration of the Internet in the transportation industry and infrastructure, the overall impact is essentially ambiguous. Innovations in online ticket sales are not likely to increase travel volume, nor is car shopping on the Internet. Directions provided by OnStar may allow travelers to pick an optimal route and decrease traffic congestion. However, wrong or incomplete directions may cause worse congestion than before. It also is not clear whether transmetrics will encourage people to spend more time in their cars than before.

One of the largest ambiguities is the combined effect of online sales and EVMS computers. EVMS allow for efficient use of trailer space, which may decrease the number of trucks on the road. However, new e-commerce purchases may add to the demand for trucking. The net result could be positive, negative, or neutral. These are only a few potential questions that need to be answered with further study, but it may well be better to wait for more national studies to be done and better data to be developed before trying to work out the implications for Florida specifically. One possible exception is discussed below.

3. PUBLIC INFRASTRUCTURE: INTELLIGENT TRANSPORTATION SYSTEMS

The national Intelligent Transportation Systems (ITS) program began with the Intelligent Vehicle Highway Systems Act in the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991. Currently, the U.S. Department of Transportation, various state departments of transportation including the Florida Department of Transportation (FDOT), and numerous centers such as the Texas Transportation Institute are engaged in a large research program relating to ITS. ITS is perhaps the only area in which information technology and the Internet have clear-cut implications for transportation through allowing FDOT to more efficiently plan for and utilize its existing transportation infrastructure, regardless of the impact of the Internet on the final demand for transportation. For example, the use of intelligent traffic systems potentially allows states to combat increasing traffic congestion, speeding, and other traffic violations. These systems use centralized traffic signal control, freeway management, electronic toll collection, and advanced emergency response to aid traffic flow and decrease costs associated with wasted gas, accidents, and lost time. It

is estimated that Maryland's statewide highway monitoring system has saved \$30.5 million while the initial investment was only \$4 million. Atlanta estimates the total benefit of their smart system to be \$44 million. It is estimated that the market for these public sector systems will be near \$75 billion in fifteen years, one-fourth the size of the private sector market over the same time period but still considerable (The Brookings Institution, <https://www.brookings.edu/dybdocroot/es/urban/ITS.htm>). Links in FDOT's virtual library provide a great deal of information about current ITS deployment and research.

Work by economists, which is summarized in Anthony Downs' book *Stuck In Traffic* (1992) and Winston (1985 and 1992) has documented the impossibility of getting efficient traffic and infrastructure investment patterns without some form of efficiently administered congestion pricing. Yet, to date, congestion pricing had proven to be politically and administratively infeasible. Thus, we are still stuck in traffic, with no sign of getting un-stuck anytime soon. Technologies related to ITS might allow us to escape from this box by creating opportunities for creative and flexible strategies to generate the proper incentives to internalize congestion externalities and generate efficient investment funding. One can imagine volunteer programs in which drivers who avoid congested areas are paid rebates, once the technology has been developed and deployed to allow anyone to participate who would choose to do so.

Since peak demand is very inelastic, charging the efficient (probably large) congestion toll (or, alternatively charging a high gas tax and providing a large rebate for avoiding congested areas) will not shift much traffic off peak. However, socially efficient investment calls for funding for the marginal unit of infrastructure to be linked to peak demand (congestion fees), not average demand (gas taxes). Thus, such a scheme would indicate where additional infrastructure would be most valued and would generate enough revenue to actually increase infrastructure. Once such programs are feasible, a great deal of study will be required to select the optimal program and toll levels. Unfortunately, however, that date does not appear to be immediately around the corner.

4. TECHNOLOGY AND URBAN FORM

TELECOMMUTING

The concept of telecommuting did not begin with information technology but with the invention of the telephone. Much like the Internet, the telephone met with great fanfare and ideas about revolutionizing business, transportation, and ending traffic congestion. As Salomon (1996) and Zavergiu (1998) separately point out, the telephone did not substitute for travel, rather it was a complement. Telecommunication advances reduced the number of short trips, but expanded the size of business markets, which increased rather than decreased traffic.

Internet technologies, however, are quite different than those of the telephone. Hughs and Nelson (2002) note that broadband technologies make different work relations possible such as telecommuting from home or even from telecommuting centers. Indeed, the telephone is limited in that data could not be sent via the phone to a person at home. Now files may be transferred via email, instant messenger, or even direct connection to the company intranet through the cable modem or DSL. Apparently Mokhtarian and Bagley (2000, hereafter referred to as M&B) performed the first survey to identify that workers would prefer to telecommute rather than work at the office if given the option. Even a mixture of telecommuting (either at home or at a telecommuting center) and office time was preferable to always being in the office.

The optimism from the M&B study is however muted because it is based on a survey of people's *perceptions* of telecommuting. The sample has few active telecommuters so responses may be based on false beliefs such as how telecommuters are viewed in a boss's eyes. They might also be underestimating the importance of social interaction. Salomon (1996) points out that there is an inherent need among people to be part of a group or society, whether for culture or status. Merely because telecommuting is an option, does not mean workers will use the option nor does it mean firms will allow employees to take the option. Therefore, no conclusions can be drawn from M&B without further empirical testing among current and former telecommuters.

Salomon (1996) points out that there is little empirical evidence that the new information economy is a substitute for current forms of communication aside from some marginal trips. However, there is increasing recognition that for the most part, the two technologies exhibit complementarity rather than substitution. Any trips eliminated by substitution are replaced by newly generated trips. One item ignored by current literature on the subject is that telecommuting may be a substitute for higher compensation with ebbs and flows coinciding with economic cycles as companies try to keep their best workers happy during labor shortages and high growth. Similarly, companies may be more interested in keeping staff focused on the bottom line and therefore in-house during recessions. Even if the Internet does spur telecommuting, if workers can make fewer trips to the office, they may choose to live further away, so the trips they do make will be longer. Thus, the net effect on transportation demand is ambiguous.

FIRM DISPERSION

Firms are utilizing Internet technologies in an effort to reduce costs and increase profits. Innovations such as the telephone and Internet have made it possible for firms to change structurally. Rather than having accounting and business divisions in the same physical building, these technologies have allowed companies to move support services like accounting into lower rent regions. Further, some companies may now find it beneficial to contract out payroll or other divisions due to the economies of scale of specialization. That is, hiring a firm specializing in payroll may be a more economical option for a large corporation rather than keeping a small staff in house to perform the same task. Sassen (2001) suggests even corporate headquarters may move from cities to suburbs, or small towns. Allen Scott (as cited in Anas et al. 1998), observed dispersion in the 1980s, nearly half a decade before the official start of the Web in 1995. Anas et al. (1998) assert that cities have been decentralizing for two centuries so, like telecommuting, this is not an Internet phenomenon. Advances due to the telephone and Internet may be part of a trend rather than individual shocks, though more research is needed.

The shift from a compact city core to a city with several sub-centers, however, reveals the impact of communication technologies and transportation innovation as facilitators of dispersion. As firms vertically disintegrate, the dispersion creates new agglomeration in different areas. Agglomeration can be explained as the interdependency among firms in the same or in different industries that lead to clustering in the same geographic area (e.g., financial district). As the level of agglomeration increases, new sub-centers develop. While the central business district (CBD) of the city remains important, the sub-centers may result in a different type of city—a network city. Network cities are not new concepts but are increasingly prevalent as firms begin to take advantage of lower rents in the periphery of the original city core. The decreasing cost of communication paves the way for several types of polycentric, or network cities. Batten (1995) identifies three such types.

The first type, called a corridor city is two sub-centers connected by a highway. Often they are between a traditional city core and an airport or research university. Batten (1995) describes the corridor city in the Swedish context as the most “synergistic” factor leading to higher growth.

American examples of the corridor city include Dulles-Washington, D.C. and the Route 128 corridor in Boston, two areas that recently experienced high growth. The second type is a set of several clusters of sub-centers connected centrally through the traditional city core. Los Angeles is loosely described as a type two city and has been modeled with as many as eight sub-centers. The final type is a combination of the first two. A high-speed corridor connects several traditional city cores and the cities interact and grow together. The research triangle formed between Durham, Raleigh, and Chapel Hill, North Carolina is an example of this network city type. It is not clear from the research why these examples formed network cities, nor is it clear how they formed. Further research on these two questions will increase the understanding of how transportation infrastructure and local economies encourage network cities to develop. It may be possible to exploit these findings to develop policies that increase economic development.

MODELS OF URBAN FORM

Monocentricity

An early attempt to model the city came in the form of a monocentric model. The model assumes that cities revolve around the CBD where all jobs are located. All workers reside in a uniformly distributed ring around the CBD. It is also assumed that housing is durable and that land use is Pareto optimal.¹ Anas et al. (1998) credit Fales and Moses for empirically justifying the monocentric model as displayed by nineteenth-century Chicago. Fales and Moses calculated that Chicago had nearly eighty percent of the city's jobs located in a four-mile span during that time period. Despite the empirical support, the model has shortcomings. It is a static model that does not account for growth and change and does not reveal any insight into the recent city trend of sub-centers and decreased density.

Table 1 depicts the density estimates for Boston, Chicago, and New York throughout their history. The density gradient represents the rate at which population density falls as distance from city core increases. A higher gradient means a more centric population. As the table shows, every city has become less centric with Chicago becoming the most dispersed over time.

The monocentric model assumes that workers will commute into the city for their jobs. However, as the city becomes more dispersed the costs of commuting increase and would therefore constrain the size of the city as workers will not be willing to move beyond a certain point to travel to work. The calculations in Anas et al. (1998) provide no evidence for this assumption.

¹ Pareto optimality is an economic concept that describes a use of goods (in this case land) by individuals and firms such that there is no way to use the goods that makes one person better off without making another worse off. Any change in how the goods were utilized would make at least one person worse off if it makes another better off.

Table 1. Population Density Gradients, Available Years

City	Year	Density Gradient (per mile)
Boston	1900	0.85
	1940	0.31
Chicago	1880	0.77
	1900	0.40
	1940	0.21
	1956	0.18
New York	1900	0.32
	1940	0.21
	1956	0.18

Source: Anas, Arnott, and Small (1998)

Polycentricity

Polycentric models were developed to help explain the pattern of dispersion. As presented earlier, the polycentric model for Los Angeles explains the dispersion experienced well as the city expanded from five to eight sub-centers. However, polycentric models do a poor job of predicting commuting distance and patterns. One explanation for this is that a two-worker household could be commuting to two different sub-centers, which would affect their choice in housing location as they attempt to minimize distance between work destinations. Local amenities such as schools, neighborhood, race, and other quality of life factors will also affect the decisions of future homeowners.

Both model types are useful by adding to our knowledge of urban form, yet Anas et al. (1998) point out that neither the monocentric nor polycentric models effectively explain commuting patterns. Indeed, the paper concludes:

Agglomeration economies have resisted attempts to fully understand their microfoundations. This is illustrated by urban economists' lack of confidence in forecasting the effects of the communications revolution on urban spatial structure. (Anas et al., 1998)

This surmise handicaps anyone wanting to estimate how the Internet will affect transportation in the context of urban form. Coupled with a lack of a significantly long and wide panel of data on Internet penetration rates, it is doubtful that it will be possible to disentangle the implications of the Internet for urban form in Florida in the near future. Again, it would probably be better to wait for more national studies and better data before doing work related specifically to Florida. Two possible exceptions are covered below.

5. HISTORICAL PERSPECTIVE: INTERNET v. OTHER INNOVATIONS

The first two sections described ways in which the Internet could change industry and infrastructure. With the exception of the specific finding of 13 percent more capacity utilization in trucking, little was said about how large the particular impacts covered may be, or how large the induced effects on transportation demand might be. If the impact of the Internet is confined to a few relatively small sectors of the economy, we would expect the aggregate effects on transportation needs to be small. If, on the other hand, computers and the Internet continually spur development across many sectors of the economy, aggregate impacts on the transportation system might eventually be quite large, even if existing evidence has not pinned them down specifically. Therefore, we now consider studies that have tried to quantify the effect of information technology on the economy broadly.

THE INTERNET AND PRODUCTIVITY

For some time, MIT economist and Nobel laureate Robert Solow summed up economists' views on the impact of information technology when he said, "We can see the computer age everywhere but in the productivity statistics." He recanted that view recently when it finally became clear that computers and information technology were having some impact on measurable economic growth. Oliner and Sichel (2000) seek to quantify that effect to determine if it was behind the strong economic performance of the late 1990s. They conclude that the strong economic performance of the late 1990s was indeed driven by computers and information technology to a large extent.

In the same issue of *Journal of Economic Perspectives*, Robert Gordon (2000) estimates that the

Table 2. "Group of Five:" Historical Innovations by Category

Category	Components
I. Electricity	Electric Light Electric Motors
II. Internal Combustion Engine	Plane Auto
III. Molecular Innovation	Petroleum Natural Gas Chemicals Plastics Pharmaceuticals
IV. Entertainment and Communication	Telegraph Telephone Phonograph Popular Photography Radio Motion Pictures Television
V. Plumbing and Sanitation	Running Water Indoor Plumbing Urban Sanitation Infrastructure

Source: Gordon (2000) pp. 59-60

productivity impact of the Internet is significantly less than that of five historical innovations (Table 2). Gordon believes that unlike past innovations, the Internet, specifically the Web, to a large degree merely duplicates processes already available through television, newspaper, and other media. He also believes that adoption of new technology has less to do with productivity and more to do with employee satisfaction, employee recruitment, and competitive “keeping up with the Joneses” philosophy (pp. 69 -70).

In comparing historical innovations to computers, Gordon (2000) observes the price of computer power has declined at an unprecedented rate. Coupled with diminishing returns to fixed factors (the users time), this may well mean that a lot of the gains have already been realized. For example, while computers are much more powerful, it takes ever more complex software to provide perhaps smaller gains in the usefulness of applications. This has been aptly captured by the expression “*What Intel giveth, Microsoft taketh away.*” Gordon (2000) further asserts that the productivity growth beyond trend experienced in the 1990s that might be attributed to information technology occurred through growth in that sector and indirectly through stimulated growth in the manufacture of durable goods. The remaining 88 percent of the economy was largely unaffected. This echoes Salomon’s (1996) prediction that the “silent majority” would remain unaffected by the new economy.

More recent evidence appears to be leading most macro-economists to adopt a position closer to Oliner and Sichel (2000). On balance, there is reasonably clear evidence that productivity growth has increased since the mid 1990s in a diffuse way, rather than simply being confined to a small portion of the economy. It is an open question as to how much of this is due to information technology, and how much is due to other characteristics of the “new economy,” such as deregulation and an increased ability to easily lay off less productive workers during economic downturns. At any rate, the implications for transportation demand and infrastructure needs are the same as in earlier sections. To the extent that the Internet increases efficiency, it tends to both increase and decrease the demand for transportation. At this point serious shifts in transportation planning due to supposed impacts of the “new economy” seem unwarranted.

6. CONCLUSIONS AND RECOMMENDATIONS

The Internet, and information technology more generally, permeates many aspects of our personal and business lives. That does not mean that it will alter trends in transportation demand significantly, although it will certainly play its part in that ongoing trend. For example, the Internet is clearly creating opportunities for direct shipping of products to final customers. However, some of this increased demand for direct shipping will simply be offset by declines in catalog orders. While electronic vehicle management systems (EVMS) increases the efficiency of trucking, declines in effective prices lead to more shipping. Depending upon demand elasticity and other parameters relating to the technology of shipping, the result could be either more or fewer trucks on the road.

In a broad sense, the Internet is part of an ongoing downward trend in transportation costs. While it will probably contribute to the dispersion of cities, that trend has been ongoing for two centuries or more, and can hardly be attributed to the Internet. Similarly, while information technology seems to be one component of a recent boost in productivity growth, we should not expect increased transportation demand as a function of an economy that is skyrocketing due to the arrival of the “new economy.”

Perhaps the clearest impact of information technology on transportation in Florida will come through its impact on transportation planning and management. Electronic toll collection and emergency services are two areas in which ITS has already contributed to transportation management in measurable ways. When related technologies become more fully developed and dispersed so as to allow interaction with most of the driving population, they may finally allow more efficient congestion pricing strategies to be developed, in turn enabling socially efficient investment policies.

While there are a great many questions about what the Internet might mean for Floridians generally and transportation needs in Florida specifically, for the most part the prudent course seems to be to wait for more national studies and more data to develop before making generalizations or conducting studies specific to Florida. We do note three areas where specific additional study related to Florida might be useful to FDOT. Since they represent three disparate areas, we are not certain which FDOT might wish to pursue, and it is not clear that BEBR would be best suited to carry out all three studies, we do not develop a detailed proposed scope for any of the three. Rather, we note broadly what each would entail, from our perspective, these are discussed in Appendix A.

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APPENDIX A -

IMPACT OF EVMS ON FLORIDA'S TRANSPORTATION SYSTEM

Florida is a peninsular state and a tourist destination. Therefore the finding that EVMS has increased capacity utilization in the trucking industry by 13 percent may have specific implications for transportation in Florida. FDOT might find a study tracing out the implications of this finding for Florida to be useful. Such a study would involve 5 steps.

- Step 1. Quantify the pattern of trucking in Florida.
- Step 2. Identify the portion of the market that might be affected by the possible improvements in capacity utilization. This would mean, in large part, finding out if it is possible to obtain better back-haul matching for trucks moving into and out of Florida, given Florida's status as a tourist destination and a peninsular state.
- Step 3. Quantify the effect of the gain in efficiency on the price of shipping services and the price elasticity of demand for truck shipments in Florida.
- Step 4. Use these parameter estimates to gauge the potential increase or decrease in truck traffic in Florida spurred by EVMS.
- Step 5. Since EVMS results in a lower intensity of utilization of transportation infrastructure to move a given quantity of goods, consider whether FDOT should engage in policies to further spur the dispersion of EVMS, such as providing real-time information.

IMPLICATIONS OF CORRIDOR CITIES FOR TRANSPORTATION PLANNING

Information technology might encourage dispersion not through allowing workers to telecommute from any location, but rather by encouraging electronic links between one city and either another nearby city, a city sub-center, or a nearby research center such as a university. These electronic links will encourage commuting between these locations, which will in turn cause development to spread out along the corridor between those locations. The direction of ongoing dispersion – all around existing cities or between cities and other nearby population centers – should be of great concern when deciding where to place new infrastructure. Thus, FDOT might find a study of the broad incidence of this phenomenon in Florida and the likely locations of continued growth along these lines to be useful. This study would consist of 4 steps.

- Step 1. Identify existing corridor cities in Florida
- Step 2. Determine the extent to which improvements in information technology have driven their development.
- Step 3. Address the potential for continuing growth of information technology to continue to spur this kind of growth.

Step 4. Determine areas where this type of growth pattern seems likely to create a need for additional transportation infrastructure in Florida.

TREND AND EXTENT OF TELECOMMUTING IN FLORIDA

It is possible at this time to survey employers in Florida to determine the level and trend of telecommuting and the perceptions of why it is or might be valuable to Florida's workers and firms. This might lead to implications for overall transportation demand or indicate patterns of demand shift that have implications for transportation planning. This study would consist of four steps.

- Step 1. Identify groups to target to gain the most useful information on a fixed budget.
- Step 2. Develop the survey instrument.
- Step 3. Conduct the survey.
- Step 4. Analyze the results to determine their implications for transportation needs in Florida.