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Title:

E-Commerce: Implications for Supply Chain Productivity, Carrier Competitiveness, and Efficient Allocation of the External Costs of Transportation

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Abstract

This paper reviews the trends in market penetration of information technologies (IT) and electronic commerce (EC) in the United States. It maintains that IT and EC have fundamentally changed today's global transportation and distribution systems. Application of IT and Web-based transactions has significantly reduced supply chain costs and improved logistics efficiency. The longer-term implications of IT and EC for intermodal mode share, industry consolidation, and allocation of the external cost burden are also likely to be far-reaching. Industry competitiveness is changing as the diffusion of the new information networks creates new alliances, accelerates consolidations, and displaces some of the supply chain intermediaries. Intermodal mode share is likely to shift towards all-highway and air-highway modes as demand for time-definite deliveries grows. As freight volumes grow, congestion externalities and the environmental costs of goods-movement are likely to mount. The gap between the full costs of expedited truck delivery and the charges paid by the users is likely to grow wider, partly reflecting the shift in the burden of funding urban highway projects downstream to state and local funding agencies. Research is needed in new decision-support systems and innovative solutions to strike an optimal balance between the tremendous benefits of the digital age and the growing social and environmental costs of a highway-centered freight transportation system.

1 - IT and EC: Trends and Impacts

The digital revolution, coupled with developments in global trading patterns and alignments, has significantly changed the conventional production and distribution practices of the past two decades. The dynamics of the new information economy -- encompassing IT and communication systems in general, and EC in particular—have transformed freight transportation and supply chain productivity. These transformations can best be understood by outlining their evolution through three overlapping phases of development, from the post-World War II period to the present.

The Early Mainframe Phase - The first widespread IT use in the U.S. was the application of mainframe automated accounting systems. This period began in 1945 with the marketing of the Electronic Numerical Integrator and Computer (ENIAC). This early period, lasting through the late 1960s or early 1970s, had a relatively limited commercial scope of application. During this period, mainframe and minicomputers were used to automate and organize a number of back-office functions, including customer and payroll accounts.

The impact of computers on national productivity during this period was significant, even though the scope of application was limited to internal administrative functions. Labor productivity figures for the 1968-73 period (the earliest period for which consistent

statistics are available) show an average annual growth rate of 2.66 %. Almost all this growth was attributed to labor productivity gains resulting from the increased capital input as computers were substituted for labor. Increased labor skill did not begin to enter productivity figures until two decades later. ⁱ

The PC and EDI Era - This phase, which moved the computer to the front office and extended its powers outside the walls of the corporation, lasted from early 1970s to the early 1990s. Around 1968, Electronic Data Interchange (EDI) was introduced, enabling computer-to-computer exchange of routine business information in standard data format. Application areas included purchasing, pricing, inventory status, shipping and receiving, and invoicing. EDI transactions during the early part of this period were conducted exclusively on mainframe computers and private communications systems called value-added networks (VAN). Later in the 1980s, with the advent of the personal computer, computers moved from the back office mainframes to the front office, and began to automate a large number of white-collar clerical tasks. This is when computers – as client/server systems consisting of interconnected local area networks (LAN) – became a management tool for streamlining clerical functions and improving the corporate bottom line.

The impact of computers on national productivity statistics during this phase, however, was minimal. Labor productivity for the 1973-79 period grew at an average annual rate of 1.27 %. The productivity growth in the latter part of this phase (1979-1990) was even lower, with an average annual growth rate of 1.22 %. It was at this point when economist Robert Solow, an MIT Nobel Laureate, commented that “*We see computers everywhere except in productivity statistics.*” ⁱⁱ This was, however, a critical phase in the development of the digital age in the U.S. Investment in IT as percentage of the GDP grew from 4.9 % in 1985, to 6.1 % by 1991.

The Age of the Web - The third wave of IT growth in the U.S. coincided with the global spread of the Internet in 1991 and the public introduction of the World Wide Web browser technology in 1994. ⁱⁱⁱ Between 1993 and 1999, the number of computers connected to the Internet worldwide grew from 1.3 million to 56.2 million. The number of Internet users grew from fewer than 5 million in 1993 to some 100 million in 1999. ^{iv} Revised U.S. Department of Commerce estimates for the number of on-line users for 2000 were 250 million, and for 2005, 350 million. ^v

Electronic commerce (e-commerce,) defined as the “*automation of commercial transactions using computer and communications technologies,*” ^{vi} encompasses two distinct business and consumer components: ^{vii}

- Consumer retail or business-to-consumer transaction (B2C) were estimated at \$15 billion in 1998.
- Business-to-business transactions (B2B), involving exchange of finished or intermediate supplies between firms, were estimated at \$35 billion in 1998 after starting at \$8 billion a year earlier. Early estimates of B2B volumes ranged

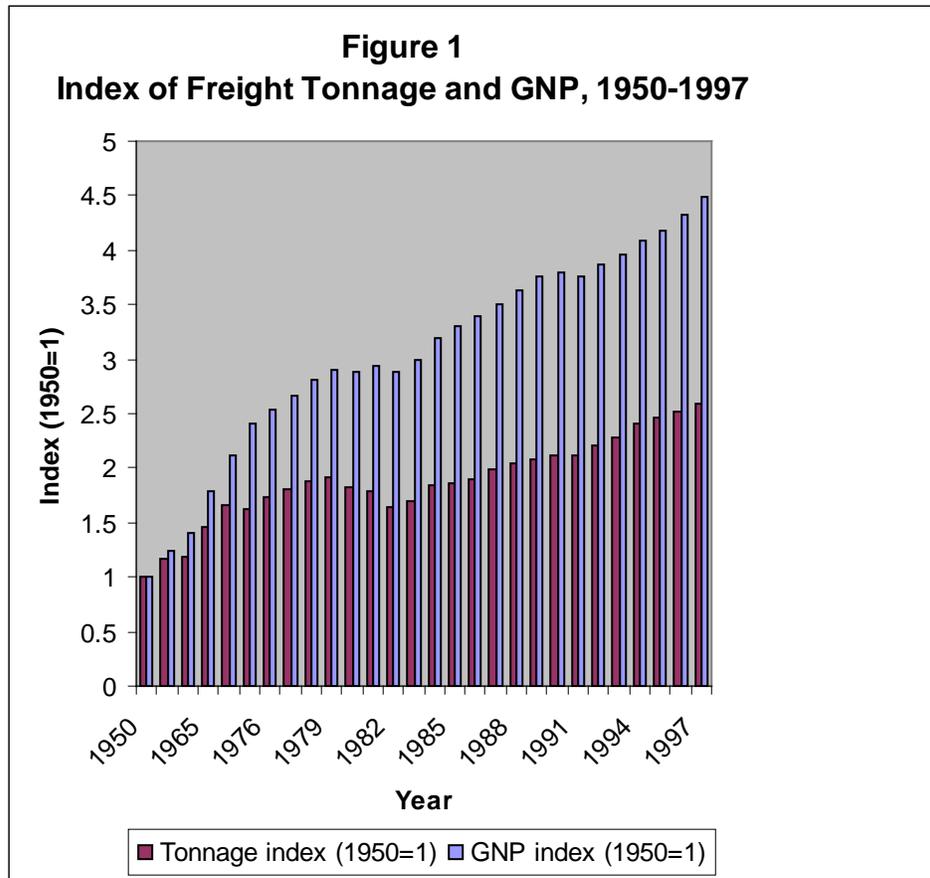
between \$114 billion and \$300 billion for 2000. By 2003, these transactions are expected to be between \$1.1 trillion to \$1.6 trillion.^{viii}

The productivity impact of IT and EC during this third phase of the new information economy has been far-reaching. The explosive growth since the commercialization of the Internet is reflected in the robust economic growth figures. The productivity figures have also begun to reflect the effect of computers in the economy. The overall national rate of productivity for all industries in the 1990-1997 period was 1.3 %. In 1998, the quarterly and annual productivity rates began showing wide swings, ranging from growth rates of 2.7% to 4.2 %.^{ix}

The spread of EC has also raised IT's share of the Gross Domestic Product (GDP). Between 1993 and 1998, the IT share of the U.S. economy rose from 6.4% of the GDP to 8.2%. Contribution of IT to the growth of GDP has been even higher. For the 1993-98 period, IT on average accounted for 35 % of the nation's real economic growth.^x

Complicating the task of measuring the impact of IT on the U.S. productivity rates is that the economy is increasingly moving towards service-sector activities. The U.S. manufacturing had a robust annual labor productivity growth rate of 4.1 % in 1998, second in the world only to Germany's 4.3 % annual rate of growth. The share of manufacturing in the U.S. economy, however, has been declining while the share of the service sector has been rising. The service sector grew from 58% to 74% of the GDP between 1960 and 1998; while manufacturing declined from 28% to 18% of the GDP. The service sector accounts for an even larger share – 80 percent – of jobs. The service sector –with some of the highest (e.g., productivity growth of 7.1% for computer retailing) and lowest (e.g., productivity rate of –2.8% for newspapers) growth rates in the economy— presents a complex set of problems when assessing the productivity impacts of IT.

The shift in the composition of the national output away from manufacturing is partly due to the change in the composition of assets in the economy. Intangible assets (e.g., knowledge-based services, software and information systems) have grown relative to the tangibles and material goods. Output in tons is roughly the same as a century ago, but 20 times greater in real value. This trend is illustrated in Figure 1, showing that the growth in tonnage in the US has been at a far slower pace than the growth in GDP. Relative to the base year of 1950, the index of total tonnage transported has grown by 2.5 times while GDP has grown nearly five-fold.



Source: The Census Bureau

2 – Impact of IT and EC on U.S. Logistics Efficiency

The economic impact of the infusion of IT in all facets of U.S. transportation and distribution services has been to boost logistics efficiency. The cornerstone of many business strategies to improve logistic efficiency is to deploy IT to raise the bottom line. A Commerce Department study has shown that 60% of the logistics costs of all Fortune 500 companies are spent on transporting goods from the manufacturer to distribution centers or retailers. Transportation figures represent 2% to 8% of these companies' total sales. So, for a multimillion-dollar business, even reducing costs by 1% adds up to substantial savings.

Over the past three decades, the corporate quest for supply-chain efficiency has spawned an array of process-reengineering efforts and just-in time (JIT) inventory-control strategies designed to cut costs, increase speed and asset productivity, and boost overall productivity. IT has played a key role in ensuring the success of this quest. The U.S. annual logistics bill – currently estimated at \$920 billion – has not grown as rapidly as the

economy as a whole, partly thanks to the productivity effects of IT. As a percentage of GDP, logistics expenditures declined from 20% of GDP in 1960, to 9.9% in 1999.

Today's greater logistics efficiency is partly due to the improved productivity of the channels of distribution, i.e., a network of institutions needed to produce and market a service to the customer.^{xi} To bring a product from factory to customer, a succession of functions is required to coordinate the marketing and supply channels. IT has been an integral part of these efficiency gains, most notably in areas of inventory carrying and order processing.^{xii}

Inventory Carrying Costs - Business inventory carrying costs as a percentage of the GDP declined from 8.2% in 1980 to 4.1% in 1997. Inventory cycle times have declined from 28 days to 2 days. To reduce inventory-carrying costs, businesses have resorted to strategies to integrate transportation and warehousing, either through vertical integration or outsourcing. WalMart, for instance, vertically integrated when it purchased a complete trucking fleet. This created a "virtual warehouse" for WalMart, transforming its old warehouses into a moving virtual storage facility.

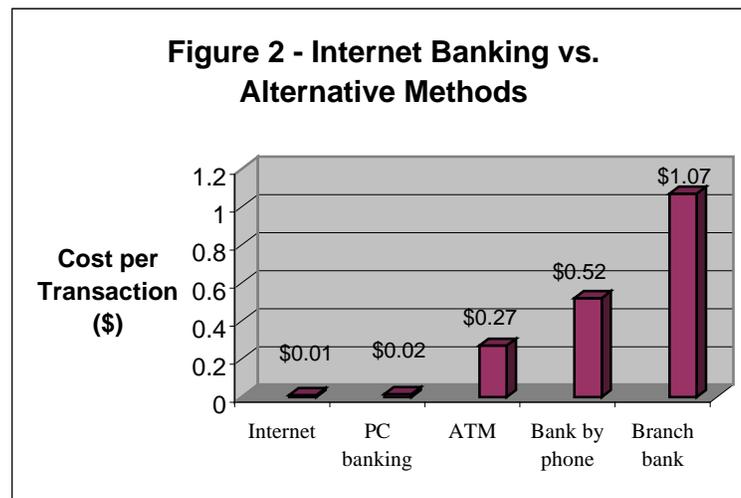
IT has also allowed producers to place "inventories on wheels" by outsourcing the warehousing and transportation functions to a single carrier. General Motors (GM), for instance, reduced its logistics costs by outsourcing these functions to Federal Express (FedEx) and its electronic Inventory Management Systems. FedEx now owns and operates one of GM's automobile component warehouses in Memphis, Tennessee, maintaining a buffer stock of components available for delivery to any GM production site overnight from this warehouse. This enables GM factories to operate on a JIT schedule for the delivery of components, with no inventory buffer, by simply placing an electronic order via FedEx's on-line system from any site nationwide.

The *Build-to-order (BTO) production* model is another strategy for reducing inventory-carrying costs. Dell pioneered the lower-cost, direct marketing of computers in the mid-1980s, with a BTO approach that represented a departure from the traditional "build-to-stock" model used for third-party distribution. This practice allowed Dell to reduce its inventory carrying costs as well as the risk associated with price protection.

IT has also helped manufacturers to keep their production and inventory carrying costs to a minimum by enabling them to "mass customize." Driven by the changing nature of scale economies and minimum plant size, manufacturing firms have been able to shrink the scale of production, making load sizes increasingly smaller and geographically dispersed. Motorola, for instance, makes pagers in its Boynton Beach, Florida, plant in up to 29,000 different varieties in lot sizes as small as one. A Motorola sales rep can design the customer's pager on his laptop and dial in specifications to the factory to produce and deliver on demand. Such a reduction in the average load size has significant ramifications for cargo volumes.

Order Processing and Transaction Costs – Thanks to the widespread market penetration of EDI, and now the Internet, order processing and transaction costs for

businesses have been significantly reduced. Estimates of EDI cost savings range from 10 to 50 percent of the transaction costs. Electronic transactions have also reduced product order cycle times. Average manufacturing order times have declined 10-fold, from 22.5 weeks in 1980 to less than two weeks today. The magnitude of change in transaction costs can best be illustrated by comparing the costs of banking costs via the Internet with those of traditional branch banking, ATM, or PC-banking. Figure 2 shows that processing a single check at the branch bank costs \$1.07; by phone \$0.52; by ATM \$0.27; and via the Internet \$0.01.



Source: Department of Commerce, <http://www.ecommerce.gov/ecommerce.pdf>

The Web has the potential to reduce EDI costs to near zero, making the benefits of the Web platforms to small operators significant. For the small shipper or carrier, a neutral web platform would significantly reduce transaction costs, given that the cost of EDI enabling is relatively high. Many Web platforms that allow extended markup language (XML) documentation to perform some of the functions have reduced the need for EDI “bootstrapping” significantly.

3 – Economic Impacts of IT and EC on the Transportation Service Industry

IT and EC have had a profound impact on the costs, competitive structure, performance, and externalities relating to transportation service. The sections that follow address five such areas of impact, discussing how EC and IT have:

- a) changed the industry costs;
- b) altered the industry’s competitive structure;
- c) changed the role of the carrier and industry intermediaries;
- d) accelerated the growing imbalance in freight mode share; and

- e) exacerbated the problem of congestion and environmental externalities.

A – EC and IT have Lowered the Industry Costs

Information technology, the global reach of markets and trading partners and innovative manufacturing strategies has coalesced to change the cost structure of today's supply chains. Stable prices, low rates of inflation, along with robust growth rates in jobs and the economy, are all indicators of the strong influence of the digital revolution on costs and prices. The exponential drop in the price of computing power nearly 25% per year over the past several decades is part of the reason. The declining cost of computing is the corollary of Moore's Law, named for Gordon Moore, a founder of Intel Corporation, which maintains that "*the processing power of microchips doubles every 18 months.*" Other costs have also declined, partly due to the growing logistic efficiency and greater competitiveness of the markets. For instance, the average ratio of price-markup-over cost in manufacturing has dropped from 19% in the 1970s to 15% in the 1990s, a testimony to the growing competitiveness of the international markets.

Today's Web-based transactions by and large have been accomplished by lowering costs without raising prices. Anecdotal evidence suggests that B2B Internet transactions have not led to any significant price markups. Any increase in profitability that transportation carriers have had has been through improved efficiency. A survey of 250 of the largest U.S. freight shippers, conducted in April 2000 by Morgan Stanley Dean Witter on the impact of EC on shipment patterns, has indicated that costs are not likely to rise significantly in the near future. Only 8% of the surveyed shippers believed a carrier could justify higher rates as a result of EC. With an estimated 35% waste and inefficiency in the industry, many analysts believe that Web-based service providers can improve their bottom line by eliminating waste without raising prices. In some markets, the Web has allowed the carrier to offer more value-added services than in the past, thus increasing revenue per transaction and the overall market-share.^{xiii}

Costs have plummeted in spite of the declining relative importance of economies of scale in manufacturing production. Economies of scale in production have become less pivotal as the location of production has moved closer to final consumption markets and the scale of production has become smaller. While volume still plays a decisive role in determining costs, new production technologies have allowed the break-even point to be reached at a lower production volume.

Plummeting information and computing costs have also had a profound impact on how businesses are using computers and the Web. Order-of-magnitude increases in communication capabilities, coupled with order-of-magnitude decreases in costs in the past decade, have led to changes in the way firms conduct business. Also significantly influencing the cost trends is a unique attribute of information networks relating to a powerful "critical mass effect." The larger the number of people who use information networks, the more valuable they become. This is referred to as the "network effect," and involves an exponential growth in returns as the volume increases. The network effect is related to the notion of returns to scale. Traditional production costs were based on

constant or increasing returns to scale, depending on the nature of the fixed costs and whether the marginal costs of production declined or stayed the same with volume increase. Though traditional products also have important economies of scale, the scale is rarely exponential.

Web-based businesses are able to attain the critical mass and density required to capture their target market, as the cost to service any incremental additions drops to close to zero.^{xiv} In information-based production systems –where bits as opposed to atoms are produced-- the fixed costs are the only relevant costs. The marginal costs are close to zero. The average cost of a bit-based product falls exponentially with volume and, eventually to zero. Whatever it costs to make the first copy of a digital product, be it \$1,000, \$1 million, or \$1 billion, the cost of the second copy is virtually zero. The fixed costs remain relatively constant with volume. But once a critical mass is reached --a point at which the additional revenues cover the fixed costs-- the value of the network grows exponentially. Metcalfe’s Law (named for Bob Metcalfe, inventor of Ethernet and founder of 3Com) states that “*the cost of a network expands linearly with increases in network size, but the value of network increases exponentially.*”^{xv} As networks expand toward infinity, they become dramatically more useful and cost-effective.

B – IT and the Web Have Changed the Nature of Industry Competition and the Intermediaries

The Web and the Internet, coupled with enhanced IT networking capabilities, have altered the nature of competition in the transportation/supply chain logistics industry. EC has redrawn the corporate boundaries and raised the performance bar for all participants. Competition now is between networks and supply chains. Competition is also for *access* to customers –as they have grown increasingly demanding -- hence the wave of mergers and alliances we are now witnessing.

One outcome of the Web-based competition is that the focus of corporate strategies has shifted to external resources and affiliations. The Web offers businesses opportunity to deliver all or substantial portions of their business activities directly on-line. The evolution of IT application from *internal* focus to improve back office productivity, the front-office operational efficiencies have been followed by a shift towards more of an *external* emphasis. This shift has necessitated a growing reliance on a public infrastructure—whether for information and transportation networks, or for public goods such as research and development (R&D) and training.^{xvi} [This highly critical shift is further addressed in Section E below.]

The nature of competition has also changed because the Internet and the Web have eliminated what used to be the “tradeoff between richness and reach,” as Evans and Wurster put it.^{xvii} By “richness” they mean the quality of information as defined by the user: accuracy, bandwidth, currency, customization, interactivity, relevance, security and reliability. By “reach” they mean the number of people who participate in the sharing of

that information. Before the emergence of the Web, it was possible to share extremely rich information with a very small number of people, and less rich information with a large number, but impossible to offer extreme levels of both simultaneously.^{xviii} Pre-Web supply chain practices of companies such as Toyota, point out Evans and Wurster, are good examples of corporate strategies maximizing the use of “rich” information, with focus on few long-term suppliers. The pre-Web position of Citibank’s currency traders represented strategies that placed greater premium on reach. The Web has eliminated the need for tradeoffs by allowing greater reach simultaneously with an information-rich communication content.

Eliminating the need to trade off information-rich content with reach can result in displacement of the intermediaries: the so-called “*disintermediation*” of the channel operators of the pre-Web era. When the bundled high-reach/information-rich Web enables the original suppliers and the ultimate consumers to transact directly, the intermediaries find themselves with little business. Evan and Wurster use the example of Dell to illustrate how a company can forge a new competitive balance in the computer manufacturing industry. Dell was able to offer lower prices by bypassing the retail link and instead selling directly from a catalog. It offered selection without tying it to in-store inventory, eliminating most of the finished-goods inventory. Through this process, the company coordinated the supply chain by exchanging information with suppliers electronically, sharing with them production scheduling, demand forecasts, and other information via the Internet. Dell’s entire supply chain is linked, allowing the firm to reduce response time, eliminate even more inventory, and respond quickly to changing customer demands.^{xix}

Web-based supplier and customer service strategy are based on a production strategy that substitutes the “pull” for the “push.” Instead of forecasting demand and using inventory as a buffer against uncertainty (the push strategy,) the pull strategy simply responds to it. Instead of directing suppliers, Dell allows them to look directly into its network and respond to the signals. The outcome is that all production lags and the need for buffer inventory have been eliminated. Dell’s on-line presence has evolved into a continuous source of support and problem solving, incorporating many functions of a Web site operator. The disintermediation of the computer retailers, in this case, was not at the expense of richness of customer support or supplier linkage.

The Web has also impacted competition by raising the bar on minimum carrier performance requirements. To the extent that raising performance benchmarks is likely to lead to greater concentration in some carrier segments, the impact on competition may be significant. A recent Morgan Stanley Dean Witter survey suggested that the Web is likely to lead to greater carrier consolidation.^{xx} Fifty percent of the surveyed shippers viewed EC as justification for using fewer carriers, a strategy reflecting the growing customer preference for one-stop shopping. An alternative scenario is that the newly Web-enabled small operators will change the competitive environment by offering services in niche markets, thus counteracting the trend towards greater concentration.

C – EC and IT Have Changed Role of the Carriers: Emergence of Reverse Auction Sites, “Virtual Marketplace,” and “Market-Facing Systems.”

Freight transportation was a relative latecomer to Web-based markets. Now, however, exchange sites and reverse auction markets are emerging as an increasingly popular method for purchasing transportation service. Exchanges, electronic marketplaces, bulletin boards and portals are the terms used in reference to the new electronic markets that have been spawned by the Internet. These exchange sites allow carriers and service providers to amplify their business objectives and promote their brand in a market that is becoming increasingly more competitive. The sites help the carriers gain speed in introducing their product to the market, or expand globally. By 2004, by one estimate, more than 50% of all on-line sales will be via e-marketplaces. According to the same estimate, by 2004, 25% of all transportation and warehousing sales are likely to be online (accounting for 3% of all B2B online sales,) with 13% via e-marketplaces.^{xxi}

Does the emergence of the Web mean that the functions of the carrier or the firm will become less important? Are we moving toward a “virtual transportation system” that reduces the need for a corporate entity? For a number of reasons, this might be a premature expectation. The Morgan Stanley Dean Witter study cited earlier concluded that virtual exchanges and e-marketplaces are not expected to have any immediate effect on contract patterns in the foreseeable future. The survey indicated that 70% of the surveyed businesses conducted transactions under contracts of a year or longer in duration. Web customers have indicated that asset-based, technology savvy firms will do better on the Web than virtual exchanges with no asset base, partly because of shippers’ concern for peak period delivery performance. On the whole, the “buyer-centric” web sites (such as exchanges and auction sites) are not as popular as “seller-centric” carrier web sites because the customers feel they need the asset assurance. The dominance of seller-centric sites is partly because of unwillingness of the consumers to pay for web operations. Often the only navigators that are adequately built and maintained are the seller affiliated ones.

A better way to describe the impact of the Web on transportation carriers is to see it as part of the on-going corporate reengineering process. The so-called “market-facing” companies are one such system that pull together various services to conduct business electronically and enable a customer’s market experience to be defined entirely on-line. The premise of such an enterprise is that the value of any one company’s IT investment is directly dependent upon the investments of the related IT “ecosystems” they participate in externally. As one industry executive has put it: “*What your company can do with technology is inseparable from what your customers, suppliers, and partners can do with technology.*”^{xxii} Typical market-facing systems include customer self service solutions offered by Amazon.com and Fed Ex that allow customers or businesses to meet their needs on-line. Another example of a market-facing enterprise is Shell Oil Company. Shell’s Supplier Managed Inventory system has arrangements with customers whereby Shell is permitted to proactively anticipate customer requirements and to forecast its own production needs more accurately. Shell’s computers directly monitor the customers’ oil

inventory levels and automatically issue replenishment requests. This process fundamentally changes the traditional transaction mechanisms, by eliminates order/delivery paperwork, as a Shell executive describes: “When you get up in morning, you don’t have to call the water company and order 30 gallons of water for your shower; nor do you have to pay your local water company every time you turn on the faucet.”^{xxiii}

D - EC and IT are Likely to Accelerate the Trend in Shifting Freight Mode Shares

A significant and possibly alarming outcome of the increased market penetration of IT and EC is the likely acceleration in the shift in domestic freight mode share away from rail and waterways, towards all-highway movements. There is also a chance that the consolidation trend among the U.S. transportation carriers will have a detrimental effect on the viability of small intermodal carriers, including short line railroads and barge operators.

The U.S. modal balance is increasingly shifting to the single-mode highway, as railroads lose market share. The rail mode share has been declining in the past four decades across the board in all key indicators, while the trucking sector has been gaining market share. In 1997, railroads accounted for 35% of all domestic intercity ton-mile, but only 13% of the tonnage, 7% of the revenues, and 4% of the value of shipments. The trucking sector in the same year accounted for 39% of the ton-miles, 69% of the tonnage, 80% of the revenues, and 72% of the total value of the products shipped.

By all indicators, the widening gap between truck and non-highway modes in domestic freight service will continue to increase with the growth in EC. The April 2000 shipper survey conducted by Morgan Stanley Dean Witter indicated that 70% of the respondents expected their freight transportation needs to change as a result of EC. Of these, 65% said they would use more parcel/express envelope service, 57% expected to use more regional or national less-than-truckload (LTL) carriers, and 53% expected to use more local trucking or courier service.^{xxiv} Twenty one percent of the respondents expected to use less rail as EC becomes more prevalent. The Web features most valued by the survey respondents were real-time tracking and tracing, on-line service performance reports, electronic bill presentation and payment, and transit time. While all Class I railroads offer these capabilities, most survey analyses place a greater emphasis on the limitations of slower speed and less-than stellar on-time performance of rail service.^{xxv} The growing market demand for expedited and time-definite freight delivery, and the widening imbalance in the freight mode-shares, are likely to exacerbate the existing freight infrastructure congestion and environmental externality problems. The implications of this outcome are addressed in the following section.

E – EC is Likely to Exacerbate the Problems of Congestion and Environmental Externalities

As efficient as private markets are in meeting the consumers' needs for private goods, they are imperfect when it comes to producing products with public-good attributes. Private transportation markets falter when it comes to investing in infrastructure facilities needed for dealing with negative externalities of growth. Where environmental or "free rider" externalities exist, the prevailing pricing mechanisms for allocating transportation services fail. As demand for these under-priced facilities exceeds the supply of highway infrastructure, capacity bottlenecks, congestion, and deteriorated air quality are the outcomes.

The Internet provides a prime example of an economic externality where positive and negative effects coexist. On the positive side, the Internet exemplifies the tremendous success of a large-scale infrastructure project that, because of its size and the public-good nature of its benefits, would not have been feasible to undertake with private funds. Another positive externality of the Internet relates to the generation of the "network effect." The benefits of these networks increase as the critical mass of the users increases, making the consumption of the system's information content more valuable as more users are added. On the negative side, the Internet is likely to shift transportation costs downstream and to non-users, as demand for time-definite highway freight delivery grows.

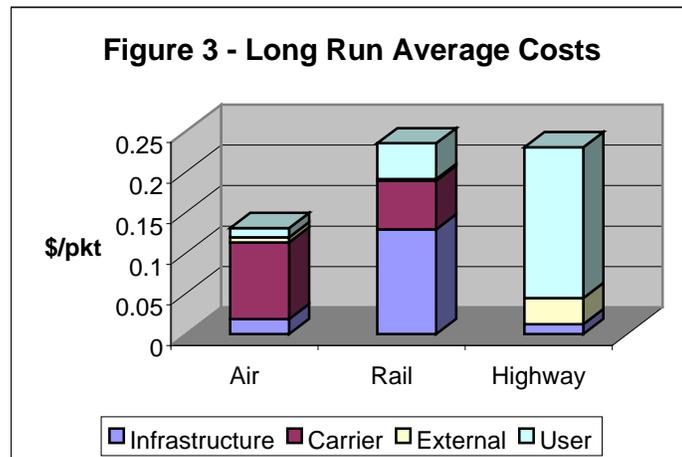
Web shoppers, by placing a premium on next-day delivery of the goods and on direct control and tracking of the delivery process, are relying increasingly on the expedited highway and air modes. The consequence of this trend is that we fail to fully utilize more efficient intermodal alternatives. Total economic losses from traffic congestion and delays in 70 urban areas were estimated at \$74 billion in 1996. The costs averaged at \$629 per driver for all cities, and \$1,200 per driver in Los Angeles, the most congested city in the U.S.^{xxvi} As a Federal Express executive remarked at a recent e-commerce conference, "*the marketplace has not yet recognized the true cost of home delivery.*"

With the rise in Web-based commerce, the full costs of providing freight transportation service are likely to be shifted to non-users or to state and local governments. A growing number of localities have found that sales tax measures have become a major part of the local funding source for surface transportation programs. Fuel taxes are no longer a direct measure of highway use. Improvements in motor vehicle technology and the development of alternative fuels have weakened the link between tax revenues and vehicle miles traveled (VMT). VMT-based user fees based on distance traveled offer an efficient solution for counteracting traffic congestion and revenue constraints. Many state transportation agencies are using highway user-charges, based on actual distance traveled, time of day, location, truck weight and number of axles, as strategic tools designed to generate revenue, mitigate congestion, and improve air quality and safety.^{xxvii} These agencies have been deploying technologies for electronic toll collection (ETC), automatic vehicle identification (AVI) and the Global Positioning System (GPS) to facilitate VMT-based user fees.

The gap between the charges that are necessary to cover the full costs of moving freight on a given facility and what users pay is getting increasingly wider. Growing highway

congestion and deteriorating air quality are some of the symptoms of this widening gap. A study on congestion pricing in the Twin Cities area estimated the gap between the “directly borne” and “marginal costs” of operating a vehicle on certain segments of the region’s urban freeway system to be as much as 50 cents per vehicle mile. The study estimated the system’s total congestion costs by calculating an “aggregated daily gap” of nearly \$1.5 million on the entire network.^{xxviii} The full, long-run costs of alternative transportation systems include the internal costs of building, operating, and maintaining the highway infrastructure, as well as the carrier, user, and social costs (i.e., net private and external costs due to emissions, accidents, and noise.) These would account for the true resource costs used in making and using transportation services.

In a study of the full costs of three alternative modes of intercity transportation in the California corridor, the research team compared the costs of light rail, existing passenger air, and highway transportation, showing that the full costs of light rail (including new infrastructure) and highway were approximately the same for rail and highway modes. The full costs for light rail were \$0.235 per passenger kilometer traveled (pkt). For highway, the full costs were \$0.230 per pkt. The highway mode had the highest levels of external costs, while light rail had the highest internal costs (i.e., infrastructure, carrier, and user.) The study concluded that externalities represent 1% of the full costs of high-speed rail, 6% of the full costs of air travel, and 14% of the full costs of highway travel. Infrastructure costs represented 55% of the full costs of high-speed rail, 14% of the air system, and 5.2% of the highway system. Carrier costs accounted for 72% of the air system, 26% of the light rail, and zero percent of the full costs of highways. User costs (out-of-pocket and time costs) accounted for 9% of the air mode, 18% of light rail, and 81% of the highway mode.^{xxix} Figure 3 shows the long-run average costs of the three modes within the study corridor.



Source: D. Levinson, A. Kanafani, And D. Gillen, 1999.

Research findings suggest that *congestion pricing* is the only effective mechanism for alleviating high levels of highway truck traffic. Congestion pricing represents an array of pricing mechanisms used for efficiently allocating and pricing the scarce highway

capacity. Technology-driven congestion-mitigation devices such as road sensors, variable signs, dynamic routing, and other intelligent transportation systems (ITS) solutions have been tested as innovative strategies for reducing congestion. The consensus, however, is that these strategies by themselves will not eliminate congestion. ITS devices are proven effective in reducing congestion only when they are deployed in conjunction with congestion pricing. Congestion pricing strategies to combat excessive levels of commercial vehicle traffic run the gamut from simple pricing mechanisms such as electronic tolls, to “smart traffic pricing” tools, and ultimately to auctioning solutions that “bid in real-time” the use of the freeway segments.^{xxx}

Congestion pricing is based on the principles of marginal cost pricing, i.e., charging the highway users a fee equal to the increase in the total system cost resulting from one more vehicle trip. Empirical evidence suggests that marginal cost pricing in transportation is practical to implement, conducive to cost recovery, and likely to result in substantial net benefits to society. One of the seminal studies on this subject estimated the net gain to the economy as a whole from optimal highway pricing and investment to be close to \$8 billion a year (in 1982 dollars), equivalent to half the annual highway maintenance expenditures.^{xxxi} Charging different rates for auto and trucks --reflecting the differential impacts of each vehicle type on emissions, pavement durability, and highway carrying capacity -- is one method of combating urban congestion.

Concluding Remarks

Powerful communication and information networks have been pivotal in elevating the Web to the center stage of the global commercial transactions. We have only begun to understand the transportation and economic impacts of the immense capabilities afforded by the new IT systems and the Web. Many of the economic gains in the past decade have been due to the rises in productivity that have allowed us essentially “to have our cake and eat it too.”

The new networks and information systems, coupled with a rich intelligence-laden content, have allowed greater scope and market reach to all participants in today’s global commerce. The cost savings, market reach, and the knowledge depth afforded by these new IT systems have profoundly impacted every aspect of global trade flows. The benefits of these networks reflect a unique network effect, such that the larger the number of people who use them, the more valuable they become.

In the competitive arena, IT and EC have fundamentally transformed the nature of competition. The Web has shifted the focus of corporate strategies to external resources and affiliations. Competition now is between networks and supply chains. The greater interdependencies among firms have made corporate competitive strategies closely linked to those of their customers and suppliers. The Web-based network has redrawn the corporate boundaries, raised the performance bar for all participants, and changed the

competitive position of many firms by allowing them to extend their reach and increase market dominance.

Sustainability of the Web-based e-commerce is closely tied to the viability of the Nation's domestic transportation network. We need to develop a better understanding of how e-commerce is impacting transportation demand, highway capacity, urban bottlenecks, intermodal market share, and the environment. The "point and click" world of the Web-based commerce has not obviated the need for the old economy "bricks and mortar" infrastructure. After all, the majority of the Web-based transactions have a physical component and a need for door-to-door delivery. The shift to the digital age has led to a growing reliance on public infrastructure and networks. New corporate and governmental strategies are needed as we encounter the reality of congested ports, airports, and highways. Research on the fundamental principles of this new knowledge-based economy, and sound methodologies and decision-support systems for arriving at optimal solutions for the changing dynamics of our networked economies are critical for the continued viability of our global logistics network.

ⁱ *Monthly Labor Review*, U.S. Department of Labor, Bureau of Labor Statistics, <http://www.bls.gov/>

ⁱⁱ Robert Solow, *The New York Times book Review*, July 12, 1987.

ⁱⁱⁱ The Internet was opened to the public for commercial use. It was created in 1969 by the Department of Defense as a fault-tolerant (i.e., able to recover and operate despite damage to one or more components,) proprietary military-university packet switching network, named ARPANET. The World Wide Web was created in 1989 at the European Laboratory for Particle Physics to provide easy access to pages of information through hypertext links.

^{iv} Department of Commerce, *Towards Digital eQuality*, U.S. Government Working Group on Electronic Commerce, Second Annual Report, 1999. <http://www.ecommerce.gov/ecommerce.pdf>

^v DOD, *Towards Digital eQuality: The U.S. Government Working Group on Electronic Commerce*. 2nd Annual Report, 1999. <http://www.ecommerce.gov/ecommerce.pdf>.

^{vi} Definitions are adopted from J. Christopher Westland and Theodore Clark, *Global Electronic Commerce: Theory and Case Studies*, The MIT Press, Cambridge, MA, 1999.

^{vii} "Commercial" here is defined as "activities that seek to create arm's-length transactions between firms and individuals and involve the exchange of money, goods, or obligations." This definition of e-commerce purposely excludes inter-organizational systems such as e-mail, fax, Internet phone, as well as internal computing that uses information systems for accounting, sales, inventory, treasury, or personnel functions.

^{viii} The lower figure estimates for year 2000 are by Goldman Sachs, the higher by Forrester Research. The Year 2003 figures are based on the International Data Corporation (IDC) estimate of \$1.1 trillion for business-to-business transactions and estimated \$1.6 trillion by the Forrester Research.

<http://www.internetcapital.com/b2becommerce.html>.

^{ix} Bureau of Labor Statistics: Economy at a Glance, <http://www.bls.gov/eag.table.html>.

^x U.S. Department of Commerce, *The Emerging Digital Economy II*, June 1999, <http://www.ecommerce.gov/ede/>

^{xi} DJ Bowersox, B.B. Cooper, DM Lambert, and DA Taylor, *Management in Marketing Channels*, McGraw-Hill, 1980. Quoted in J.C. Taylor and G.C. Jackson, "Conflict, Power, and Evolution in the Intermodal Transportation Industry's Channel of Distribution," *Transportation Journal*, Spring 2000.

^{xii} Westland and Clark, p. 22.

^{xiii} E-Commerce for Freight Conference, June 14-16, 2000 Las Vegas, Nevada.

^{xiv} Papows, p. 38.

^{xv} Quoted in Papows, p. 38.

^{xvi} Papows refers to the IT system that creates and facilitates the on-line business transaction environment is referred to as “market facing system” sustained by the activities of “market facing enterprises.”

^{xvii} Philip Evans and Thomas Wurster, *Blown to Bits: How the New Economics of Information Transforms Strategy*, Harvard Business School Press, Boston, 2000.

^{xviii} Evans and Wurster.

^{xix} Joan Margretta, “The Power of Vertical Integration: An Interview with Dell Computer’s Michael Dell,” *Harvard Business Review*, March-April 1998, 77, quoted in Evans and Wurster.

^{xx} Morgan Stanley Dean Witter, *Freight Transportation and Logistic*, Industry Report on: *The Impact of E-Commerce: Surveying the Shippers*. April 10, 2000

^{xxi} Industry forecasts for B2B e-commerce from Forrester Research.

^{xxii} Papows, p. 11.

^{xxiii} Papows, p. 85.

^{xxiv} Morgan Stanley Dean Witter, op.cit.

^{xxv} Morgan Stanley Dean Witter, op cit., p.8.

^{xxvi} Texas Transportation Institute reports available on the web at: <http://www.bts.dot.gov>

^{xxvii} Reza Navai, “Transportation Financing: A Critical Review of Transportation Pricing.” *Transportation Quarterly*, Vol. 52, No. 1, Winter 1998.

^{xxviii} Herbert Moring, “Congestion,” in Jose Gomez-Ibanez, William Tye, and Clifford Winston, Editors, *Essays in Transportation Economics and Policy: A Handbook in Honor of John R. Meyer*. Brookings Institution Press, Washington, D.C. 1999.

^{xxix} D. Levinson, A. Knafani, And D. Gillen, “Air, High-speed Rail, or Highway: A Cost Comparison in the California Corridor,” *Transportation Quarterly*, Vol. 53, No. 1, Winter, 1999.

^{xxx} Yosi Sheffi, unpublished slide presentation, April 2000.

^{xxxi} Jose Gomez-Ibanez, “Pricing,” in Jose Gomez-Ibanez, William Tye, and Clifford Winston, Editors, *Essays in Transportation Economics and Policy: A Handbook in Honor of John R. Meyer*. Brookings Institution Press, Washington, D.C. 1999.