MOVING FREIGHT IN THE NEW ECONOMY: PAYOFFS, PERILS AND PARADOXES

DR. BAHAR BARAMI
SENIOR ECONOMIST
VOLPE CENTER

INTERNATIONAL SOCIETY OF LOGISTICS
SPECTRUM NEWSLETTER

September 26, 2000

The infusion of information technology in all industrial processes has elevated the performance of the U.S. economy to new heights. Yet our transportation system is still guided by many of the obsolete infrastructure investment and pricing paradigms of the old economy. Consequently, our freight network suffers from congestion, and environmental degradation. The network also faces severe capacity shortages in some segments and is underutilized in others. We need new accounting tools for infrastructure pricing and new strategies for incorporating the full costs and environmental impacts of network use.

1 – The New Economy: Shifts in Production and Distribution Paradigms

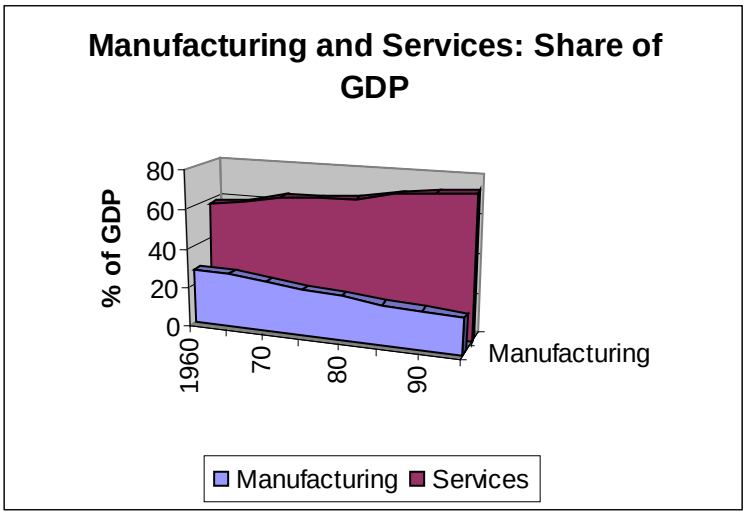
By "new economy" I mean the spectrum of changes that has transformed the rules of the economy, its structure, and functions in the past decade and a half. While the term refers broadly to many qualitative and quantitative aspects of the modern economy, it can be defined more narrowly as a "knowledge-based economy" driven by innovation, and characterized by the prevalence of technology imbedded in an array of services and manufactured products. [i]

The drivers of the new economy have been trade globalization, information technology (IT), and deregulation of transportation, communications, and banking industries in the past two decades. Four major shifts in the paradigms governing the nation's production and distribution system characterize the new economy.

Shift from a goods-producing paradigm to a knowledge-producing one. In the past half a century, manufacturing as a percentage of Gross Domestic Product (GDP) has declined steadily. In 1960, nearly a third of the domestic output was from manufacturing activities and 58 percent from services. Today, less than one fifth of the GDP is from manufacturing and close to three-quarters from services (Figure 1.) Not only is the share of services in the economy growing, but also what is left of manufacturing is becoming infused with information. With the growing share of knowledge in the production process, the economy is moving towards a 'virtual system of production," [ii] and manufacturing itself is "dematerializing." A convergence of goods and services has tilted the balance in favor of a product's information input. By one estimate, three fourths of the value-added in manufacturing are information. Whereas in the old

economy, we bought and sold "congealed resources," in the new economy, we trade "congealed knowledge."[iii]

Figure 1



Transition to a "weightless" economy. The corollary of the shift to knowledge-based economy is a two-pronged shift in production processes towards shedding material weight. First, the goods produced and distributed in the system are "lighter;" and second, the share of the "intangibles," i.e., the information and knowledge components of the value-added in GDP, is growing. In the 1950s, a beer can was made of steel and weighed about 1.5 ounces. Today, a typical beer or soft drink can weighs just 0.48 ounce. The original IBM personal computer that was introduced in 1981 came in three pieces and weighed 44.3 pounds. Today an average laptop weighs less than 6 pounds. Figure 2 shows 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 had nearly a five-fold growth.

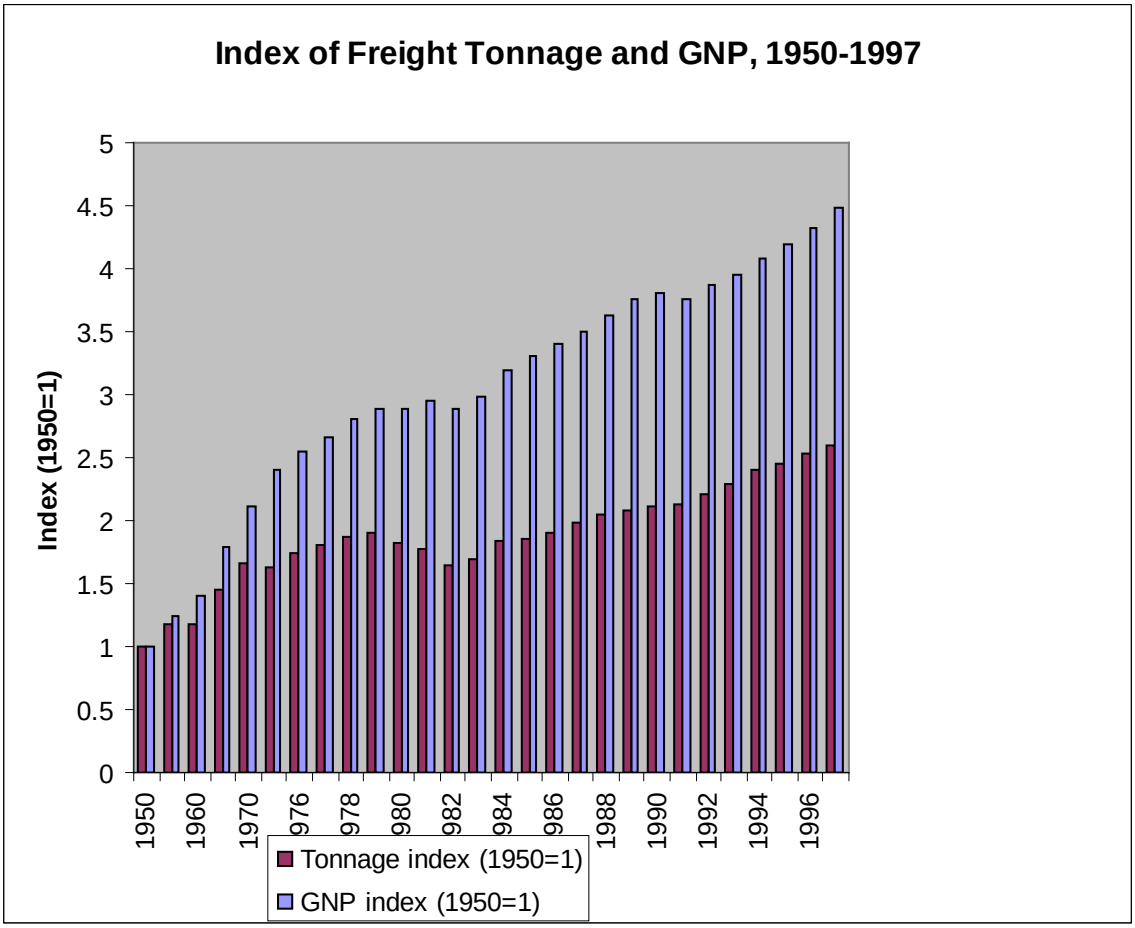


Figure 2 – Growth in Freight Tonnage and GDP

Shift from economies of scale to economies of scope. Industrial age prospered to a large extent because of *economies of scale*. Standard products could be manufactured with decreasing unit costs by increasing the volume of production. Production cost relationships changed in the 1990s. Infusion of high levels of knowledge generated *economies of scope* in production, permitting an enterprise to produce different products on the same assembly line without incurring higher costs. By moving away from mass-production to "mass customization" and build-to-order (BTO) production, manufacturers have increased the breadth of their market reach, and can maximize revenues by giving the customers precisely what they ask for. Motorola, for instance, makes pagers in a single Florida plant in up to 29,000 different varieties in lot sizes as small as one. Each customer's pager is designed on the sales person's laptop, and the specifications are dialed into the factory to produce and deliver on-demand. This practice significantly changes demand for transportation, as it reduces the average load size and increases shipment frequency.

Substitution of transportation for inventory investment. Just-in-time (JIT) production and logistics strategies have enabled businesses to substitute transportation for inventory. Inventory investment constitutes the third component –after fixed business and residential investment – of aggregate investment spending in our economy. Inventory investment has historically been highly sensitive to business cycles. In the recession years of the early parts of the 1950s, '60s, and '70s, inventory investment as a percentage of GDP dropped to zero or negative figures. When the recovery came, the ratios rose to 3.5 percent of GDP. [iv] During this period, the annual ratios of investment to final sales fluctuated between 25 percent and 35 percent.

Today inventory-to-sales ratios have stabilized at around 24 percent, from a high of 35 in 1981 (Figure 3.) Figure 3 also shows that inventory investment as a percentage of GDP has steadily declined, from 8 percent in 1980 to 4 percent in 1999. JIT inventory replenishment practices have reduced fluctuations in inventory levels, and smoothed the volatility of business cycles. Today, lower ratios of inventory investments are no longer indicative of cyclical downtruns, but rather a measure of stability. By placing "inventories-on-wheels," businesses have lowered their carrying costs without jeopardizing on-demand access to inventories.

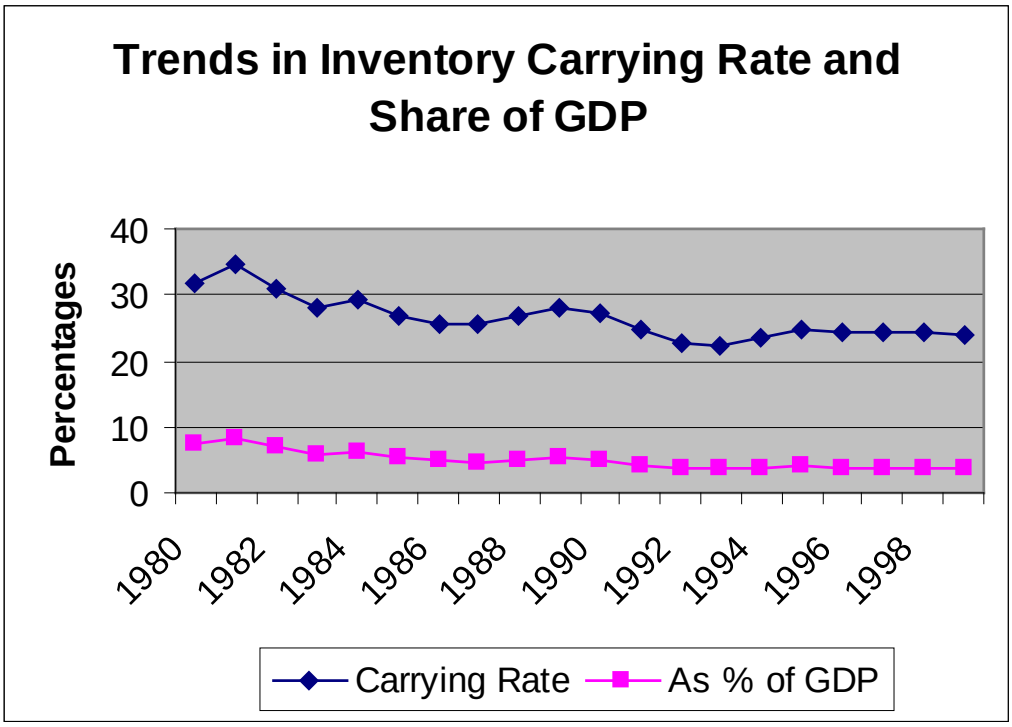


Figure 3

2 – Payoffs

The confluence of trade globalization, technological advancements, economic deregulation, and corporate reengineering of the past decade has led to significant windfalls for the consumers and producers alike. Global markets and the digital revolution have reduced transaction costs and supply prices, and increased logistics efficiency, as indicated by declining inventory carrying costs. Two key indicators of the transportation-related benefits of the digital revolution are productivity growth and the network effect.

Productivity Growth – Productivity growth allows more to be obtained in one area without producing less in others. The closest one ever comes to getting something for nothing is by increasing productivity. Productivity rises in effect allow us to "*have our cake and eat it too.*" The impact of the digital revolution on productivity, however, did not show up in national statistics until 1998, when productivity figures began to climb to 2.6 percent, and continued to rise to a record annualized rate of 5.7 percent in 2000. Other economic performance indicators also suggest robust economic growth for 2000, as indicated by GDP growth rate of 3.8 percent, inflation rate of 2.6 percent, and unemployment rate of 3.6 percent.

The Network Effect. Part of the benefit from the digital revolution has to do with the "network effect," i.e., an exponential growth in returns to IT investment as the volume increases beyond a certain threshold. This is because information networks have

powerful *critical mass* effects. The larger the number of people who use information networks, the more valuable they become.

The network effect has improved the competitive position of many smaller firms, as businesses no longer have to trade off market breadth for customized service. Electronic commerce and the Web have eliminated what has been called the "tradeoff of richness and reach."[v] Businesses can now offer high-bandwidth, customized information with rich content simultaneously with a broad market reach. Dell Computer, for instance, forged a new competitive balance in the computer manufacturing industry when it began to sell directly to end-users. By bypassing the retail link and other intermediaries, Dell was able to offer lower prices and eliminate most of its finished-goods inventory. The flow of information was key to the success of this new approach: "*We substitute information for inventory and ship only when we have demand from real end-consumers,*"[vi] as the Dell executive announced.

3 - Paradoxes

> "*Well, in <u>our</u> country,"* said Alice, still panting a little, *"you'd generally get to somewhere else –if you ran very fast for a long time as we've been doing."*
> "*A slow sort of country!"* said the Queen. "*Now <u>here,</u> you see, it takes all the running you can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that*."
>
> Lewis Carroll, *Through the Looking Glass.*

Paradox of Speed. Today speed is the primary criterion for measuring transportation performance. Our highly advanced vehicle and communications systems have given us the capability for rapid delivery of goods and information. Yet, we have done very little to shorten the end-to-end travel time when all the connections for all goods in the network are added up. This is partly because speed is highly sensitive to the "composition effect" or "neighborhood effect," and influenced by the collective behavior. Whereas I could cut my travel time from A to B in half if I traveled at 60 mph instead of 30 mph, I would not be able to do so if thousands of other travelers were also trying to get from A to B at the same time. We have shifted to faster modes –highway and air – to move faster, but the rising volumes of trucks carrying high-priority cargo have brought to a standstill the entire highway and air network. We tend to make our investment and business decisions based on a project's engineering attributes, disregarding the system-level collective impacts.

Paradox of "Weightlessness." We are learning that lower shipment weight does not necessarily leave us with less to ship, nor does it make transportation more efficient. This is because shipments have become "information-laden." We are shipping less in absolute weight, but we are transporting more cargo with precise information content, more BTO shipments, more components that need to get there JIT, more packages that need to be traced and tracked, more cubic foot of cargo, and more cargo requiring precise guidelines for temperature and hazard control. Yet we are using the old paradigm of the goods-production era to transport information-laden cargo.

The reason the old rules of moving freight no longer apply is that the lower the share of "things" and atom-based goods in the economy, the more challenging the task of managing risk and meeting performance requirements. The traditional models are not likely to lead to the outcome desired by today's shipper. Today's cargo movement is more about managing risk and information rather than moving physical volume and weight. The performance gaps occur when we fail to fully align the intermodal interfaces and human elements and connect the growing number of links in the supply chain.

Paradox of the Global Reach – We are outsourcing and purchasing goods all over the globe. Our manufacturing firms receive their supplies from around the world. Yet in our domestic freight system we are not shipping goods any further. This is partly due to today's load consolidation strategies and the location patterns of assembly and distribution centers at urban hub. The average shipment length in the US has steadily declined. An average shipment was transported 388 miles on the domestic leg of the journey in 1997, compared to 424 miles four years earlier. A typical end-to-end truck shipment in 1997 was 130 miles, down 10 percent from four years earlier. The average shipment length for goods moving on inland waterways declined even more, a 42 percent drop relative to 1993. These trends closely relate to the shift in the U.S. freight mode-share, as addressed below.

These paradoxical outcomes of the new economy translate to an array of high-cost tradeoffs that jeopardizes the continued efficiency of the new economy.

4 - Perils

The perils of the knowledge economy are threefold, and related to: a) underestimating the extent of cost shifting; b) confusing information with knowledge; and c) overdoing the "marginalist" approach to system-level improvements.

a – Underestimating the Nation's logistics costs by ignoring the shifted burden.

The net cost savings from the digital revolution and the integrated supply chains may have been overestimated. While enjoying our free lunch from the unprecedented growth rates of the last decade, we may have begun to eat other people's lunch as well. Some of the recent productivity growths in supply-chain logistics and on-line transactions may in

fact reflect the savings obtained by shifting costs to other segments of the system: downstream suppliers, local governments, and the environment.

- **Shifting Costs to Downstream Suppliers.** Much of the logistics cost-savings has been accomplished by shifting some of the burden to other sectors. Mass customization and BTO production, for instance, lead to inefficiencies in resource-use. High-volume fulfillment of individual orders raises costs, not all of which is offset by higher value-added content of the output. E-commerce so far has not raised logistics costs. We don't know yet whether productivity gains can pay for the costs of setting up on-line systems. Will on-line sales generate enough gross margins to absorb the costs of filling orders and home delivery? Can expedited cargo carriers indefinitely deliver at the old prices and not raise them? If not, who will bear the burden of the added costs? Local governments? The environment? As a Federal Express executive recently remarked at an e-commerce conference, "*the marketplace has not yet recognized the true cost of home delivery.*"

- **Shifting Costs to Local Governments.** The digital age has necessitated a growing reliance on public infrastructure and networks. Part of the free lunch that we have all been enjoying has come from a shift in the infrastructure and logistics cost burden to local governments. As a study of the current methods of transportation financing concluded: "State, local and regional governments are increasingly bearing a larger share of the transportation funding needs. Sales tax measures have become a major part of the local funding source for surface transportation programs." [vii]

- **Shifting Costs to the Environment.** The growing externalities of moving freight is another hidden cost of the global system of goods-movement. In a recent study, Professor Dellucchi of the University of California at Davis, estimated that at the national level, total annual social costs of motor vehicle use amount to $1.7 trillion to $3.3 trillion. Of the high-end estimate of $3.3 trillion, 30 percent were monetary user costs, 37 percent personal non-monetary costs such as travel time or indirect private bundled costs for free parking, 25 percent monetary external costs such as lost wages due to accidents and non-monetary external costs such as air pollution, and 7 percent public sector infrastructure costs. [viii]

  The growing demand for expedited next-day freight delivery has given rise to a modal shift in the domestic freight system away from rail and marine modes to all-highway and air. This shift is likely to raise the environmental costs of freight movement. A study of the full costs of three alternative modes of intercity transportation in the California corridor, compared the costs of light rail, existing passenger air, and highway transportation. The study showed that the full costs of light rail (including new infrastructure) and highway were approximately the same, roughly $0.235 per passenger kilometer traveled, but that the highway mode had the highest external costs. External emission costs represented 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. [ix]

b - Confusing information with knowledge

Another peril of the digital age is that widespread availability of information and raw data makes it more likely for planners and investor to regard raw data as synonymous for knowledge and valid measures of system performance. Whether it is market intelligence, tracking data for cargo in-transit, or other system performance statistics, "information" is a product of the computing system, but it is not the same as "knowledge."

Whereas *information* entails codified propositions about states of the world or explicit algorithms on how to do things, *knowledge* includes cognitive categories, codes of interpretation, tacit skills, and problem-solving techniques not easily reducible to algorithms. [x] Knowledge is costly to acquire, share, and use in new applications. To apply the old paradigms that relate to concrete attributes of "things" and "widgets" to situations requiring knowledge can be highly misleading if not risky.

Compounding the other risks associated with a knowledge-based economy is that the likelihood of making critical errors increases because knowledge is exchanged in imperfect markets. Tangible goods are exchanged in more or less "perfect markets," where buyers and sellers have full access to information about the products and where they are sold. Knowledge, in contrast, is bought and sold in markets where the exchange conditions make them "incomplete," "asymmetrical," and "local." [xi] The exchanged knowledge is likely to be *incomplete* because the buyers don't yet have "knowledge maps" and "knowledge yellow pages" to guide. The *asymmetry* exists because knowledge is abundant in some sources and scarce in others. Knowledge is also *local* because obtaining it depends on where you are, whom you know, and what sources you have access to. These attributes of knowledge, and the lure of today's abundant sources of information, pose threats to the quality of the decision-making process.

c - Overdoing the "marginalist" approach to infrastructure investment.

> *"Locating the least soggy spot in a swamp is not optimizing if high ground is accessible outside the swamp."*
>
> Arthur Okun, the former chairman of the Council of Economic Advisors[xii]

A rigidly incremental approach could lose sight of major opportunities. Excessive reliance on marginal system improvements, though the easiest to implement, is often not the most effective approach. Tinkering at the margin will not always offer the best solution, and is likely to perpetuate the stovepipes of isolated decision processes. For

example, advanced transportation technologies and ITS have been used aggressively by businesses and metropolitan areas for a decade. While the functional effectiveness of these technologies has been proven for individual applications, we don't fully know how these systems perform in circumstances involving systemic interactions and behavior change. Local optimization and piecemeal technology solutions to urban traffic may prove to be more costly when the problem requires system-level, global optimization.

One reason piecemeal transportation improvements fail to work is the "equilibrium effect." The dynamics of the total transportation network are such that any capacity improvement in one segment of the network – e.g., improving traffic flows through ITS– is likely to leave the overall capacity unchanged for two reasons. One is the "diversion effect," when traffic from unimproved segments of the network is diverted to the improved segment. The second reason is the "induced demand," whereby new trips are generated that in the past may have been foregone or taken on other modes.

5 – The New Economy Needs a New Cost Accounting Paradigm

> *"There ain't no rules around here. We're trying to accomplish something."*
>
> Thomas Edison, Circa 1872.
>
> "What is my ROI on e-commerce? Are you crazy? This is Columbus in the New World. What was his ROI?"
>
> Andy Grove, Chairman of Intel Corporation, Circa 1998

When new operating paradigms replace the old ones, disruptions occur and the old rules fail to work. This is how innovation changes things. Innovation works through the "*perennial gale of creative destruction,*" as Joseph Schumpeter called the process of new product development.[xiii] The process has continued to work remarkably well in the industrialized West. Yet, in the wake of this continual process of innovation, there have been some collateral damages too. One of the tradeoffs of the recent waves of entrepreneurial ventures has been the growing cargo-related network congestion. Our existing transportation infrastructure markets have failed to deal with the tradeoffs and externalities associated with the use of the public freight infrastructure. The future of the transportation system depends on how these tradeoffs are handled. Today, with the advanced system of shared knowledge available to us, we are uniquely positioned to develop innovative approaches for dealing with the growing external costs of moving freight. As part of these strategies:

- We need to develop a new cost-accounting paradigm to help us align the realities of the knowledge economy with the needs of the ecosystem. The new paradigm will balance the tradeoffs of economic growth with a sustainable environment by

developing analytical criteria that assess the benefits of reducing motor vehicle congestion and emissions. This will require promoting innovative pricing strategies and incentive systems to motivate users to accept more efficient methods of paying for user benefits. We have an inefficient pricing system that allows the unbridled use of the highway network, and leads to excessive levels of congestion and emission. Promoting efficient cost recovery methods such as marginal cost pricing for the use of the highway network[xiv] is one such method proven to generate substantial net benefits to society.

- We need to formulate a new set of corporate and governmental strategies and policies to deal with the reality of congested ports, airports, and highways. In order for us to successfully incorporate the full-costs of moving freight into the prices we pay, we need to "change the prevailing mindset that accepts a fixed set of tradeoffs of the environment and economic growth," [xv] as Harvard's Corporate Strategist Michael Porter has proposed. More ecologically efficient outcomes are possible only if we align investment in our freight transportation network with more efficient pricing. This means discarding some old myths about congestion, and recognizing that congestion is not self-correcting. We much create the awareness that current highway user-costs do not reflect the true social costs of operating on congested freeways. As information becomes a growing component of GDP, and the weight of the materials in trade diminishes, the full social cost of moving cargo is likely to rise, and not decline.

- Finally, we need to adopt national policies that promote a system-level approach to solving the network problems. Part of this strategy involves stemming the downward slide in intermodal freight mode-share. As alternatives to the congested highway network, the rail and marine modes are more efficient with respect to emissions and fuel use. In the past four decades, not only have the rail and marine mode-shares declined steadily, it is likely that the decline will further accelerate as the trend towards mergers and consolidation among carriers continues. The continued mode share decline is likely to have detrimental effects on the viability of small intermodal carriers, short line railroads and barge operators, and ultimately the sustainability of the environment and the U.S. intermodal freight network.

[i] "Technology, Innovation, and New Economy Project", The Progressive Policy Institute, http://www.neweconomyindex.org/. Accessed July 2, 1999.
[ii] Richard Rosencrance, *The Rise of the Virtual State*, Perseus Books Group, 1999.
[iii] Based on a study conducted at the Tuck School of Business at Dartmouth College, quoted in Thomas A. Stewart, *Intellectual Capital: The New Wealth of Organizations.* Doubleday, New York, 1997.
[iv] See Rudiger Dornbusch and Stanley Fischer, Macroeconomics, McGraw-Hill Book Company, 1978.
[v] Philip Evans and Thomas Wurster, *Blown to Bits: How the New Economics of Information Transforms Strategy,* Harvard Business School Press, Boston, 2000.
[vi] Michael Dell's statement in a 1998 interview, quoted in Evans and Wurster.
[vii] Reza Navai, "Transportation Financing: A Critical Review of Transportation Pricing." *Transportation Quarterly,* Vol. 52, No. 1. Winter 1998, pp. 71-83.
[viii] Mark A. Dellucchi, *The Annualized Social Cost of Motor-Vehicle Use in the U.S., 1990-1991: Summary of Theory, Data, Methods, and Results*, June 1998.
[ix] 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.

[x] Giovanni Dosi, "The Contribution of Economic Theory to the Understanding of a Knowledge-Based Economy," in Dale Need, G. Anthony Siesfeld, and Jacquelyn Cefola, Editors, *The Economic Impact of Knowledge,* Butterworth Heinemann, Boston, 1998.
[xi] Lawrence Prusak and Don Cohen, "Knowledge Buyers, Sellers, and Brokers: The Polictical Economy of Knowledge." In Dale Need, G. Anthony Siesfeld, and Jacquelyn Cefola, Editors, *The Economic Impact of Knowledge,* Butterworth Heinemann, Boston, 1998.
[xii] Arthur Okun, *The Political Economy of Prosperity,* W.W. Norton, 1970.
[xiii] Joseph Schumpeter, *Capitalism, Socialism, and Democracy,* Harper and Row, 1942.
[xiv] *Essays in Transportation Economics and Policy*, Jose A. Gomez-Ibanez, William Tye, and Clifford Winston, Editors, The Brookings Institution Press, 1999.
[xv] Michael E. Porter and Claas Van Der Linde, "Green and Competitive: Ending the Stalemate" in Michael E. Porter, *On Competition*, A Harvard Business Review Book, 1998.