The Food Industry Center
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Printed Copy $25.50

Re-investing in America's Infrastructure: Will it be Easy to be Green?

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December 2008

Prepared for the Freight and Logistics Symposium, Minneapolis, MN, December 5, 2008.

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ABSTRACT

President-elect Obama has proposed major spending to revitalize America's infrastructure. But how? First, where we have gone and where we are is the result of an historical co-evolution of public transportation infrastructure and private economic investment. Where we need to go is toward more efficient modes of transport that economize on fuel and energy use and reduce greenhouse gas (GHG) emissions. But how we get there is bounded to a significant degree by this past and present: what economists call "path-dependency." Second, the historical evolution of public infrastructure has been important to the U.S. economy not simply because it supplemented private sector investments, but because the public investments raised *private* rates of return over time. National highways and bridges have made possible a shift in the carrying costs of inventory, one consequence of which has been to improve efficiencies in the delivery and availability of consumer goods. As more efficiencies in the use of scarce energy are sought economy-wide, business will be forced to find concentrations of activity along the nodes of supply chains that are more efficient. These adjustments can be facilitated by public infrastructure investments allowing for flexibility in intermodal transport activity, which can be a key aspect of the new administration's national energy strategy.

This brief discussion is divided into three parts: (1) the economics of infrastructure and its relationship to just-in-time inventory management; (2) an example drawn from the food industry case of fresh fruits and vegetables; (3) recommendations for a public investment strategy that maximizes the opportunities for efficiencies along the supply chain, thus conserving energy.

Working Paper 2008-03
The Food Industry Center
University of Minnesota

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Introduction

The collapse in Minneapolis of the I-35 bridge on August 1, 2007 has become a symbol of the declining state of U.S. roads and bridges. Whatever the ultimate determination of the cause of the 2007 tragedy, no one familiar with the pattern of investment in public infrastructure would deny that substantial new improvements are needed. President-elect Obama has proposed major spending to revitalize America's infrastructure. But how? These infrastructure investments, like corresponding investments in education, health care, and public housing, require a new perspective.

First, we must be realistic about where we have gone, where we are, and where we need to go. Where we have gone and where we are is the result of an historical co-evolution of public transportation infrastructure and private economic investment. Where we need to go is toward more efficient modes of transport that economize on fuel and energy use and reduce greenhouse gas (GHG) emissions. But how we get there is bounded to a significant degree by this past and present: what economists call "path-dependency."

One of most famous contributions to understanding path dependency was made in a paper by Paul David,[1] on the subject of the keyboard. Consider the difficulty of introducing and implementing major changes in the configuration of the letters and symbols of an American computer keyboard, which largely follows the arrangement of the typewriter. When in Europe, even the slight changes in configuration are disconcerting when sending email. Now apply the lesson to the current configuration of infrastructure. Major change will require a major shift in thinking.

Second, the historical evolution of public infrastructure has been important to the U.S. economy not simply because it supplemented private sector investments, but because the public

[1] Paul A. David. "Clio and the Economics of QWERTY," *The American Economic Review* 75(2)(May 1985): 332-337.

investments raised *private* rates of return over time. Later in this paper, attention will focus on how the national highways and bridges have made possible a shift in the carrying costs of inventory, one consequence of which has been to improve efficiencies in the delivery and availability of consumer goods. As more efficiencies in the use of scarce energy are sought economy-wide, business will be forced to find concentrations of activity along the nodes of supply chains that are more efficient. These adjustments can be facilitated by public infrastructure investments allowing for flexibility in intermodal transport activity, which can be a key aspect of the new administration's national energy strategy.

This brief discussion is divided into three parts: (1) the economics of infrastructure and its relationship to just-in-time inventory management; (2) an example drawn from the food industry case of fresh fruits and vegetables; (3) recommendations for a public investment strategy that maximizes the opportunities for efficiencies along the supply chain, thus conserving energy.

(1) Public Infrastructure and Returns to Timely Investment

In 1803, Albert Gallatin (1761-1849), Thomas Jefferson's Secretary of the Treasury, drew up a bold scheme for a system of federal highways to knit together the far-flung markets of the new Union, and to overcome an emerging system of toll-roads that threatened to slow the progress of intra-continental transportation. Gallatin, a Swiss financier of surpassing intelligence, was about 150 years too early, although his proposal for the "United States Road," from Cumberland, Maryland to the Mississippi was enacted in 1806. It was constructed beginning five years later. The road eventually reached Vandalia, Illinois in 1841, just short of its intended terminus in St. Louis. In 1921, the Federal Highway Act provided federal aid to reconstruct the National Road.

But it was not until 1956, during the Eisenhower administration, that the Federal Aid Highway Act was passed, with support from those concerned over the need for rapid mobilization in the face of military challenges from China and Communist Russia. The resulting Interstate highway system, and a complementary set of interchanges and bridge connections to state highways and county roads, would alter the face of America, transforming personal travel and freight transport over a period of 50 years in ways nearly as dramatic as railroads after the Civil War.

The standard argument for investments in physical infrastructure is that they are "public goods." Nobel Prize-winning economist Paul Samuelson noted that because public goods are non-excludable (everyone can use them) and non-rival (your use of them does not reduce mine except when they are congested), there will be insufficient incentives for the private sector to supply them.[2] Hence governments will need to use their taxing authority to raise revenues for infrastructure finance. While the same argument is made by advocates of public financing for education and health care, conservatives have suggested that they can be provided by charter schools and private health care facilities. The same group is generally hostile to raising road taxes to support infrastructure maintenance and investment.

While there is little doubt that the apportionment of federal and state funds for infrastructure is subject to political influence, leading in some cases to roads and bridges to nowhere, though in the main, roads and bridges connect people and markets along new routes that are preferable to none. These are not the only examples of public infrastructure providing greater connections and networks. Beginning in the New Deal and continuing after World War II, the Rural Electrification Administration (REA) and the system of federally-built dams and

[2] Paul Samuelson. "Diagrammatic Exposition of a Theory of Public Expenditure," *Review of Economics and Statistics* (Nov. 1955): 350-52.

reclamation projects in the West and Tennessee Valley resulted in hydropower-driven electrification and irrigation that transformed the economies of many previously isolated rural and mountain areas. Major federal spending (most of it defense-related), also provided the early connections that would become the Internet (supported but not conceived by Al Gore). All of these networks not only provided direct connections—they also exhibited "network externalities,"[3] in the sense that the benefits to individuals and firms who used them was a positive function of the number of others who also did so (although these positive returns are diminished with congestion).

The key point is that these public investments not only yielded public benefits, they also raised *private* rates of return. Former Commerce Under-secretary Robert Shapiro and Kevin Hassett, in a 2005 report, estimated that in 2003 U.S. businesses and individuals derived $788.4 billion a year in direct economic benefits from highways and public transportation, mainly in lower costs and higher productivity. This was even after excluding the value of access to schools, medical facilities and other non-work related destinations. When the $185.1 billion a year in taxes and other fees used to pay for this infrastructure was deducted, it still left more than $603 billion in direct economic benefits.[4] A 2004 working paper found that a one percent increase in government spending on infrastructure raised economic growth rates by 0.3 percent over a lengthy period of time.[5] Conversely, lagging investment or disinvestment in public infrastructure

[3] Katz, M. L. and C. Shapiro. "Network Externalities, Competition and Compatibility." *American Economic Review* (June, 1985): 424-440.
[4] R.J. Shapiro and K.A. Hassett. 2005. "Healthy Returns: The Economic Impact of Public Investment in Surface Transportation." American Public Transportation Association. A comprehensive literature survey is M.I. Nadiri and T. Mamuneas, 1998, "Contributions of Highway Capital to Output and Productivity Growth in the U.S. Economy and Industries." Federal Highway Administration, Department of Transportation.
[5] David Aschauer. 1998. "Public Capital and Economic Growth: Issues of Quantity, Finance and Efficiency." Working Paper 233, p. 4. Jerome Levy Economics Institute.

constrained growth and increased congestion and continues to do so.[6] While individuals and politicians complain about road taxes and fees, they miss the fact that dilapidated highways and bridges raise the costs of slowed transport: an even higher and more punitive tax.

The macroeconomic benefits of public infrastructure result from their influence on the microeconomics of logistical decisions. A case in point is just-in-time (JIT) inventory management. Interestingly, JIT originated with an enterprise that would benefit hugely from public roads and bridges: the Ford Motor Company. As Henry Ford noted in 1923: "If transportation were perfect and an even flow of materials could be ensured, it would not be necessary to carry any stock whatsoever . . . With bad transportation one has to carry larger stocks."[7] The JIT technique was brought to modern industry by the chief engineer at Toyota, who realized that limited storage space and expensive Japanese land could be overcome by JIT methods.[8] He based his analysis on visits in the 1950's to the supermarket chain Piggly Wiggly, where the innovative use of the same methods was being applied to the food industry. While JIT is much studied as process engineering, Henry Ford's original observation linking the efficiency of the transportation delivery system to the capacity to save on inventory holdings is often overlooked. In effect, the investments in public infrastructure transfer inventory holdings from warehouses *in situ* to trucks – in which the rolling stock becomes a warehouse in transit.

(2) An Example: Fresh Fruits and Vegetables

Note has already been made of the pioneering role of Piggly Wiggly in implementing JIT methods. However, it is only in the last 20 years that supermarket chains have begun fully to integrate automated store ordering (ASO) into their perishables departments. A group of Dutch

[6] Vernon Henderson. 2000. "The Effects of Urban Concentration and Economic Growth." National Bureau of Economic Research. NBER Working Paper 7503.
[7] Henry Ford. 1923. *My Life and Work*. Doubleday: New York.
[8] Taiichi Ohno. 1988. *Just-in-Time for Today and Tomorrow*. Productivity Press. Tokyo.

authors,[9] in a survey of supermarket sales, reported the following data for a set of six supermarkets. The table shows that

	Perishables	Non-Perishables
Avg. Weekly Sales Per Product (CU)	11.9	7.9
Coefficient of Variation of Weekly Sales	0.345	0.377
Potential Delivery Frequency (days)	1.2	1.3
Shelf Life (days)	21	240
Average Case Pack Size (CU)	6	10
Minimum Inventory Norm (CU)	3.3	4

Source: van Donselaar, et al., 2005.

perishables typically have weekly sales 50 percent higher than non-perishables, and median case pack sizes 40 percent smaller, implying that the time between two orders for a perishable item is roughly 2.5 times less than for a non-perishable item, so that they must be ordered more than twice as often. Also, the minimum inventory norm for perishables is significantly smaller than for non-perishables. If this is combined with the fact that average sales are larger for perishables, replenishment for perishables poses inventory management challenges that are uniquely met by holding inventories of, say, fresh lettuce, in trucks rather than in fixed storage facilities.

But what underlies the procurement efficiencies of logistical giants such as the fresh produce divisions of Wal-Mart Supercenters and Super Target are prior investments in road and bridge infrastructure that get these deliveries there fresh and on time, offering consumers a cornucopia of healthy food choices. Wal-Mart, in particular, has applied automatic inventory replenishment to perishables. As described by Cook (2004):

> "Under this c-vendor managed procurement system, shippers have access to real-time (via satellite) store level sales data and are responsible for continually replenishing their products to each distribution center served, on a just-in-time basis, throughout the season or year for which the contract arrangement is in place. The performance of suppliers is graded and to be retained they must meet numerous standards, including a very low

[9] K. van Donselaar, T. van Woensel, R. Broekmeulen and J. Fransoo. 2005. "Inventory Control of Perishables in Supermarkets." *International Journal of Production Economics*: 462-472.

> stock-out rate. Suppliers provide services specific to Wal-Mart, such as packing in returnable plastic containers (RPCs) and category management, utilizing the electronically exchanged sales data shared by Wal-Mart."

These programs have allowed Wal-Mart's costs to fall below the competition in the fresh produce category, and appear also to have increased sales and profits from shippers in growing areas such as California's Central Valley.[10] In short, public infrastructure investments have made possible technological innovations in logistics and transport that have raised private rates of return in the food industry, while expanding both the range and healthfulness of consumer choice.

(3) Supply Chain Efficiencies and Energy Conservation

Can new investments in infrastructure and its relation to more efficient transfer of goods contribute to energy savings? On the one hand, critics of economic activity (such as critics of NAFTA) argued that more freight is more of a problem for the environment. On the other hand, more efficient handling of inventory should imply less waste. One of the key (and unanswered) questions concerns how efficient supply chains and systems of inventory, especially in food, can use less energy while maintaining consumer choice. Here industry has tended to cede the field to critics, despite the fact that it has the data to prove them wrong.

Consider local sourcing in Minnesota. In the summer, Minnesota is awash in fresh vegetables of every sort, from melons to asparagus to onions. But in the winter, it relies on shipments from California, Florida and the Southern Hemisphere. How should we weigh the advantage of such seasonal fresh food choices against the costs of supplying them year-round? Are local sources better sometimes, but not always? How much should we be willing to pay to have fresh asparagus in February in Minnesota?

[10] Roberta L. Cook. 2004. "Supermarket Challenges and Opportunities for Fresh Fruit and Vegetable Producers and Shippers: Lessons from the U.S. Experience." Paper presented at the Conference on Supermarkets and Agricultural Development in China – Opportunities and Challenges. May 24, 2008. Shanghai, China.

Evaluations of energy use in alternative transportation modes suggests that trucks, while not achieving the bulk advantages of tankers and trains, offset these disadvantages with speed (Figure 1). In effect, the tradeoff in transport is largely energy versus speed. You want it fresh and fast? It will cost energy. Thus, road transport has been responsible for the vast majority of increases in energy demands over the past 25 years. Whether the energy adjustments possible from more sophisticated inventory management can offset the additional costs of building and maintaining roads and bridges remains an open question.[11] As energy costs continue to impinge on public and private budgets, explorations of alternative pricing rules and funding mechanisms are needed.[12]

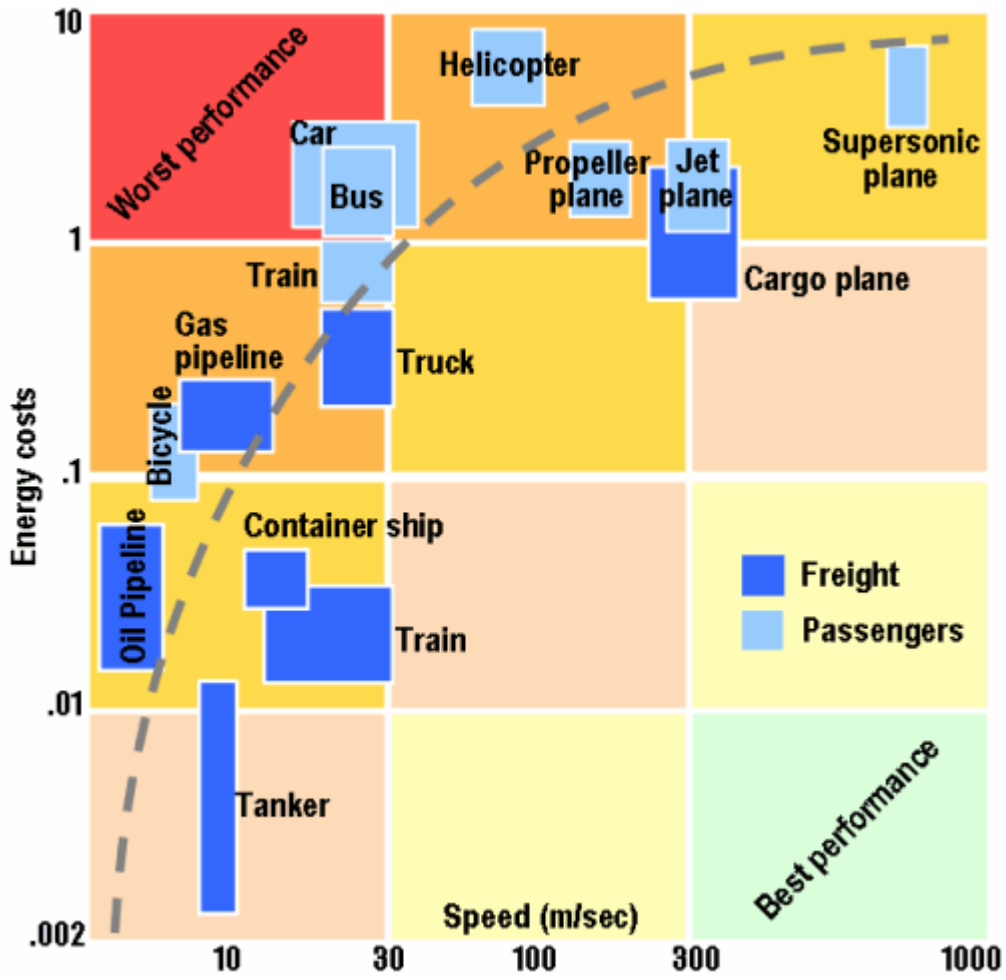
However, in any event, the role of public transportation infrastructure in facilitating new and more efficient inventory management methods is clear. By shifting carrying costs away from company-owned warehouses and into trucks, a major share of these cost savings have been implicitly supported by public infrastructure expenditures and hence taxpayers. It may now be time for a broadening of the time-honored principle of transportation economics: that the "user pays." In the past the "user" had been defined as a vehicle moving on the highway. The force of my argument is that the "user" includes wholesalers and retailers whose inventory controls are predicated on the quantity and quality of this infrastructure. This suggests broadening the tax base of support for public infrastructure to include these sectors. This might imply a ***reduction*** in highway vehicle user taxes and fees, which can be spread over the much broader wholesale and retail sectors (perhaps proportionate to sales) which approximate JIT delivery.. While this may be argued as a tax impinging on consumers, in practice wholesalers and retailers would pass

[11] See Jean-Paul Rodrigue and Claude Comtois. 2008. "Transportation and Energy." In *The Geography of Transport Systems.* http://people.hofstra.edu/geotrans/eng/ch8en/conc8en/ch8c2en.html

[12] S. Proost and K. Van Dander. 2003. "Marginal Cost Pricing for All Transport Modes and the Effects of Modal Budget Constraints." Catholic University of Leuven. Center for Economic Studies. Working Paper 2003-11.

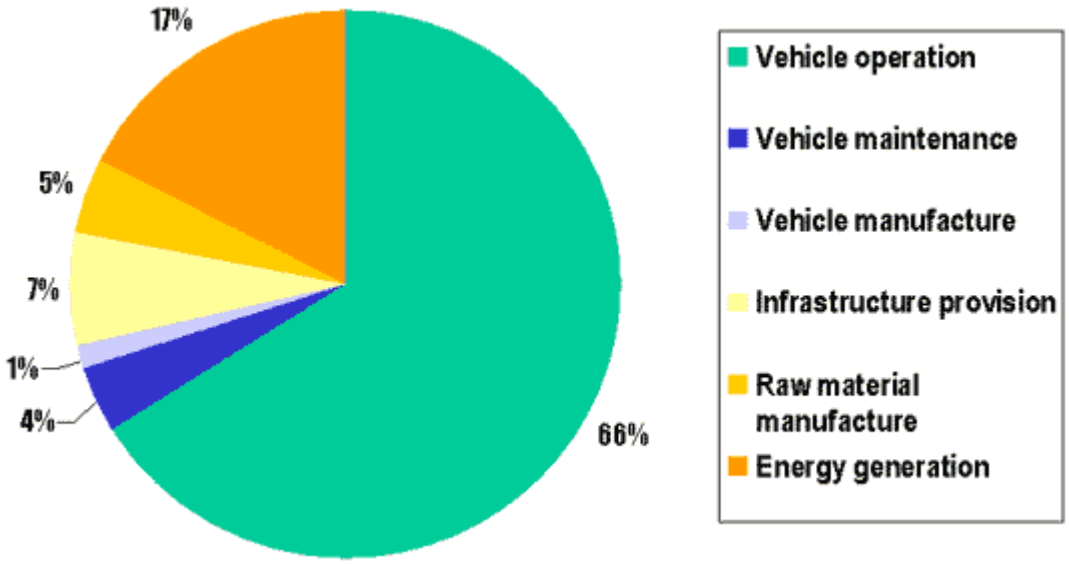
along the marginal costs as relatively small retail price increases, while truckers and drivers would experience substantial relief from road taxes. The greater challenge will be to design these incentives in ways that encourage infrastructure and technology investments to economize on fuel and energy use. This effort is underway, but an Obama infrastructure initiative could give it force.

Figure 1.



Source: Adapted from Chapman (1989).

Figure 2.



Source: adapted from R. Tolley and B. Turton (1995) *Transport Systems, Policy and Planning: A Geographical Approach*, Burnt Mill, Harlow Essex: Longman Scientific & Technical, p. 268.