



**UNDER-INVESTMENT IN TRANSPORTATION INFRASTRUCTURE:
THE HUGE IMPLICATIONS OF INVISIBLE SUPPLY CHAIN BENEFITS**

By David Jacoby and Dan Hodge

1. There has been a lot of discussion recently about how much the US needs to invest in infrastructure, and for good reason. The US has been under-investing in part because it has not been considering the supply chain benefits of infrastructure investment.
 - a. The supply chain benefits of freight transportation infrastructure investment are 1-2% of companies' operating cost and over 15-20% of their annual transportation expenditure. Governments and policy makers do not typically account for the economic stimulus provided by these supply chain benefits when evaluating large-scale infrastructure opportunities, but they should. For example, if the United States factored supply chain benefits into its project evaluation criteria, it could justify the funding for 15-30% more projects on a benefit/cost basis, and would commit almost \$7 billion per year more to transportation infrastructure than it currently does.
 - b. This article explains how businesses reconfigure their supply chains in response to transportation improvements, and highlights some high-profile projects that demonstrate how proper accounting for supply chain benefits reveals significant hidden value in many infrastructure investments.

Supply chain benefits make transportation infrastructure investments more viable

2. Shippers build supply chain costs into their network structures and operating processes, but transportation officials rarely consider decisions that businesses make to increase productivity in response to more efficient transportation systems..
 - a. Industries reconfigure their logistics processes to take advantage of transportation capital investments. In the short run, they change purchasing and operations behavior. In the longer term, they make input substitutions and reconfigure production processes to take advantage of transportation system improvements. Shippers are especially likely to adjust their behavior when there are large and visible changes in their supply or distribution networks. As recently discussed in a paper that was written by the authors for the US Department of Transportation in 2006,¹ and summarized in Figure 3:
 - i. "Shippers use lower transportation costs to extend their reach and source from a more diverse base of less expensive suppliers, which increases their margins. Often this involves global sourcing, or off-shore sourcing, as some have come to know it. As written by the author in another article:
 1. "Springfield Wire of Springfield, Massachusetts is currently sourcing 50% of its value-add on one product line from China, and has set a goal to source 70% to 90% of its externally sourced product across all product lines there. The only reason it is not shifting 100% of its production overseas is that logistics costs offset the per-unit cost savings on some

¹ "Guide to Quantifying the Economic Impacts of Federal Investments in Large-Scale Freight Transportation Projects." Credit for the contributions of that material used herein is given to Cambridge Systematics and Boston Strategies International (formerly Boston Logistics Group).



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- product lines. “Chinese labor costs just three to five percent of U.S. labor. The fully-loaded Chinese labor rate is less than we pay just for workmens’ comp in Massachusetts,” he says. The labor cost differential clearly exceeds the 25-30% unit cost savings needed to cover logistics costs, according to Richard Hundley, Director of Corporate Purchasing.”²
2. Global sourcing is not a US phenomenon; countries like Japan and Taiwan have been off-shoring to save money for years. They also deliver at lower costs per shipment. Extending reach has other benefits, too. With lower transport costs, shippers operate fewer plants (because they get greater market reach from each one), and this increases their return on assets. They may also opt to use some of the savings to ship in smaller quantities that had been prohibitively expensive at the higher rates, thereby decreasing inventory. A 10% transportation cost reduction from infrastructure investment yields 15.5% of companies’ transportation cost, or 0.5% of operating cost, according to annual benchmarking studies conducted by Boston Strategies International since 2004.
- ii. Shippers use freed-up capacity from fewer bottlenecks to reduce inbound variability of arrival times, which results in less inventory. The reduced variability allows them to downsize their fleets because they need fewer vehicles for peak-period congestion, as well as fewer spares. And with less variability they consolidate warehouses that held inventory that was buffering against the unreliability of inbound shipments due to congestion.
 1. Reducing transportation and warehouse operating costs as free-flowing linehaul routes permit the efficient operation of hub and spoke networks of cross-docks that replace traditional warehouses and shift in-warehouse inventory to in-transit inventory.
 2. Leading retailers and consumer package goods firms worldwide, such as Wal-Mart, Welch’s, Kimberly Clark, Georgia Pacific, and Blyth have created lean supply chains by instituting narrow time windows for delivery and shutting down or bypassing intermediate warehouses. Carriers like UPS offer specific transportation products geared at accelerating the trend.
 3. Inventory, fleet, and warehouse rationalization stemming from a 10% transportation cost reduction amount to 3% of transportation cost, or 0.2% of operating cost.
 - iii. Shippers use better transit time visibility – information about where shipments and vehicles are located and when they will arrive at the destination – to postpone final assembly or configuration, which increases customer satisfaction by providing a broader product mix in shorter lead times, which then increases sales and profit. The related increase in delivery reliability allows shipper to reduce

² Jacoby, David, “Strategic Sourcing Scrabble,” APICS Magazine, July/August 2005.



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both assets and operating cost. They also use in-transit visibility to monitor conditions en-route. This reduces equipment requirements by identifying potential equipment problems before they cause downtime. Better cargo tracking capabilities also enable shippers to more fully implement assemble-to-order (ATO) and finish-to-order (FTO) postponement strategies. The cost benefits of postponement equate to 1-5% of transportation cost, based on reductions in stock-outs experienced at retailers such as Wal-Mart and consumer packaged goods suppliers such as Procter & Gamble.

- iv. This being said, the biggest supply chain benefit is the potential enhancement of revenues made possible through transportation investment. Shippers can garner more revenue by reinvesting cost savings in more competitive pricing. They can also reach a broader market, facilitating increased sales at little or no incremental cost. Alternatively, they may decide to offer higher service levels (shorter order-to-delivery lead times) instead of or in addition to pocketing savings. Reliability, flexibility, and speed are hallmarks of companies with acclaimed supply chains such as Zara, the Spanish retailer. Dell Computer's much touted success in computing derives largely from its ability to customize and even personalize computers on-demand by tapping into its tremendous real-time information flow. Amazon.com maintains an analogous capability that is particularly strong in customer relationship management data. Using the data, its sales force can more easily up-sell customers based on their purchase history and browsing behavior. The sales growth of companies that make supply chain central to their business model can be more than double that of others in their peer group.

Figure 1: Supply Chain Benefits of Major Freight Transportation Investments

Shippers and carriers adjust their supply chains when new infrastructure is built, allowing them to reduce cost and increase service. Connectors, gateways, and links allow them to source from more distant suppliers at lower cost, form hub and spoke networks to reduce transportation cost, and change bulk shipments to smaller, more frequent orders to reduce inventory. Infrastructure investments that enable a 10% reduction in transportation costs *additionally* help companies reduce their overall operating costs by 1% by optimizing their supply chains.



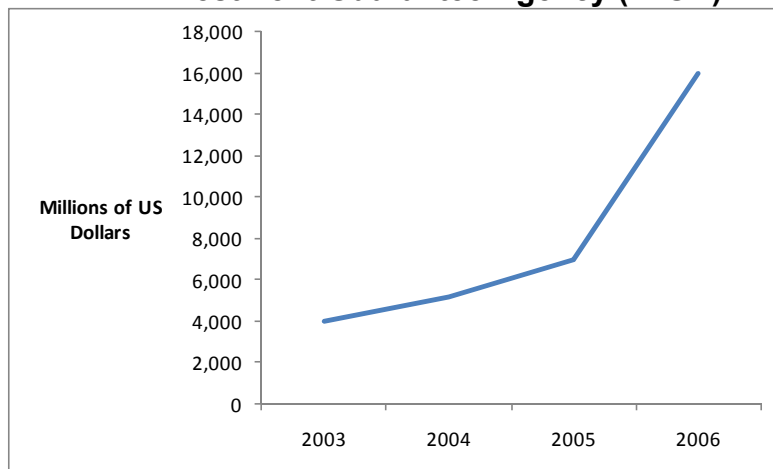
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Infrastructure Benefit	Supply Chain Impact	Supply Chain Benefit Expressed as % of Operating Costs	Supply Chain Benefit Expressed as % of Transport Costs
10% Transport Cost Reduction	Lower material cost by substituting farther cheaper sources	0.5%	8.3%
	Consolidate plants due to extended reach	0.2%	4.1%
	Switch modes and reduce shipment size, decreasing inventory	0.2%	3.1%
			15.5%
10% Capacity Increase	Less safety stock	0.2%	2.8%
	Rationalization of fleet and warehouse assets	0.01%	0.3%
			3.0%
10% Better In-Transit Visibility	Postponement benefits (cost side only)		1-5%

3. While the aforementioned examples are from the US, the same principles apply to major economies worldwide, especially large countries and economic areas where shippers can take advantage of hub and spoke infrastructure to design more economically efficient supply chains. In fact, some of the largest and most visible infrastructure investments are being made in Asia and Europe today, as those regions' economies and populations grow rapidly. Numerous mega-port projects are underway around the world, and developing economies have been ramping up their investment in transportation infrastructure, thanks in part to increasing investment from governmental agencies. For example, the volume of investment supported by the Multilateral Investment Guarantee Agency (MIGA) has more than tripled since 2003, and much of this investment can be leveraged to enable more efficient supply chains.

Figure 2: Transportation Infrastructure Lending Supported by the Multilateral Investment Guarantee Agency (MIGA)



Source: World Bank Private Participation in Infrastructure (PPI) Database



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Why are supply chain benefits ignored today?

- a. Government transportation officials and their consultants rarely account for either the short run or the long run effects in their financial evaluation of the viability of freight transportation investments.
- b. There are several reasons why transport agencies have historically not accounted for supply chain benefits.
 - i. First, many countries' capital investment agenda has shifted from a highway to a port focus, and the issues and methods do not fit so cleanly with the traditional toolbox of decision-making approaches. Since many countries spent enormous capital dollars laying networks of highways following World War II, publicly-funded transportation investments have overwhelmingly gone to highways. But today's freight transportation investment needs often involve other modes (e.g. rail, seaport) in combination with trucking to serve shipper to receiver trade. Public funds to non-highway modes are gradually being re-evaluated in terms of investment need as well as timing (responding to today's business needs).
 - ii. Second, decision-makers don't always have the time to consider every aspect of every potential project, especially for smaller projects. There are many types of costs, benefits, and investments involved in properly evaluating major infrastructure projects. For example, there are eight major types of impacts:
 1. Environmental impact
 2. Safety benefits
 3. Public operating and capital expense benefits
 4. Direct user or carrier benefits
 5. Direct shipper benefits (which includes access to terminals and possibly more efficient modes of transportation that can save time and cost)
 6. Economic impact benefits (jobs, industry and market growth)
 7. Supply chain benefits
 8. International economic benefits (trade)
 - iii. Third, non-highway modes, in particular rail and marine, have a much stronger private sector ownership element such that public investment in freight rail and marine port terminals is less prevalent and there is concern at times about public funding towards private sector activity. This is in contrast to highway and transit investments that directly address metropolitan area commuter congestion issues, which are often viewed as more of a public issue.
 - iv. Fourth, Freight transportation often involves longer point-to-point trips from shipper to ultimate receiver than metro area congestion problems. This means that a wider and more complex set of beneficiaries and jurisdictions may be required to help promote and fund freight transportation investments. This is one of the reasons that there are increasingly frequent calls for a truly national freight policy.



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- c. Some of the benefits are addressed in cost/benefit analysis projects while others are not. Environmental and safety considerations usually are considered as part of a decision-making process, and are frequently the main reason investments are initially brought up for consideration. Public operating and capital expense budgets are usually considered, as are direct user/carrier and direct shipper benefits. The economic impact, in terms of job creation or loss, of projects is sometimes considered, especially in large-scale investments where multiple constituencies or stakeholders are affected.
- d. Two types of benefits are most often omitted, resulting in an incomplete assessment of all the benefits on most projects: supply chain benefits and benefits from increased international trade. Chicago's CREATE project, a consortium of public and private parties working to develop streamlined intermodal connections and through-traffic patterns in Chicago, is one of the first projects to examine extended supply chain benefits. Figure 2 demonstrates the omission of supply chain and trade benefits by summarizing which factors were considered and which were not, in a sample of recent freight project evaluations.



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Figure 3: Consideration of Benefits in Four Proposed Freight Projects

	CALIFORNIA: INLAND EMPIRE RAIL SHUTTLE	CHICAGO: CREATE	VANCOUVER: Major Commercial Transportation System.(MCTS)	NY: CROSS- HARBOR TUNNEL
Public Operating and Capital Expense Impact	<ul style="list-style-type: none"> •Reduction in pavement wear •Fuel tax revenue 	<ul style="list-style-type: none"> •Highway investment averted 	<ul style="list-style-type: none"> • 	<ul style="list-style-type: none"> •Economic impact of operating and capital •Reduction in pavement wear
Direct Carrier Impact	<ul style="list-style-type: none"> •Savings to rail operators 	<ul style="list-style-type: none"> •Savings to rail operators 	<ul style="list-style-type: none"> •Improvement in ability of the system to maintain capacity to meet projected demand (trains, carloads and value of goods) using the rail system 	<ul style="list-style-type: none"> •Reduction in costs for existing freight rail carriers and reduction in congestion to remaining trucks
Direct Shipper and Passenger Economic Impact	<ul style="list-style-type: none"> •Not quantified 	<ul style="list-style-type: none"> •Congestion mitigation on future highway passenger traffic growth •Rail commuter time savings/ Motorist time savings at crossings 	<ul style="list-style-type: none"> •Reduction in road system delay associated with excess VKT (VMT) and VHT for commercial vehicle operations, commuting and overall highway network efficiency in the region 	<ul style="list-style-type: none"> •Travel time and reliability benefits of diversion from truck to rail
Supply Chain Impact	<ul style="list-style-type: none"> •Not Quantified 	<ul style="list-style-type: none"> •Inventory reduction savings (national assessment only) 	<ul style="list-style-type: none"> •Not Quantified 	<ul style="list-style-type: none"> •Not Quantified
Economic Impact	<ul style="list-style-type: none"> •Not quantified 	<ul style="list-style-type: none"> •Regional construction stimulus •National growth and productivity 	<ul style="list-style-type: none"> •Ability to avoid losses of gateway port economic activity (jobs and income) that would otherwise occur •Ability of the Vancouver region, BC province and Western Canada to maintain its economic vitality and importance 	<ul style="list-style-type: none"> •Business attraction/retention due to greatly enhanced freight rail service and a new intermodal yard •Economic impacts to the region and nation
International Trade Impact	<ul style="list-style-type: none"> •Not Quantified 	<ul style="list-style-type: none"> •Not Quantified 	<ul style="list-style-type: none"> •Not Quantified 	<ul style="list-style-type: none"> •Not Quantified
Environmental Impact	<ul style="list-style-type: none"> •Reduction in air and noise pollution 	<ul style="list-style-type: none"> •Value of emission reductions due to reduced train & motor vehicle idling 	<ul style="list-style-type: none"> •Not quantified 	<ul style="list-style-type: none"> •Value of emission reductions from truck to rail diversion
Safety Impact	<ul style="list-style-type: none"> •Reduction in accidents 	<ul style="list-style-type: none"> •Savings tied to accident reduction at crossings and less congested highways 	<ul style="list-style-type: none"> •Reduction in accidents 	<ul style="list-style-type: none"> •Fewer highway accidents
Total Economic Benefit	<ul style="list-style-type: none"> •\$23m 	<ul style="list-style-type: none"> •Almost \$500 million in public benefits; 1,000 jobs and \$50 million payroll 	<ul style="list-style-type: none"> •\$1.5 billion in High Impact Scenario, benefit/cost ratio of 1.6 	<ul style="list-style-type: none"> •\$0.6 billion personal income for the U.S. and 29,000 jobs in NY metro area by 2025 in double-tunnel system

1. The “Guide to Quantifying the Economic Impacts of Federal Investments in Large-Scale Freight Transportation Projects” quantified supply chain benefits at 15-20% of transportation costs, or about 1% of operating costs based on a sample of a wide variety of industries (see Figure 3 below):



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The Supply Chain Benefit Impact in One Infrastructure Decision

- a. The Baltimore Rail case referenced above serves as a useful case study of supply chain benefits in the US. This project involved the commitment of about \$3b toward new tunnels beneath the city of Baltimore and alternate alignments that would bypass the city to resolve congestion in and around Baltimore. There are multiple stakeholders. Railtrack is shared by freight and passenger rail, and is owned by several companies. The need to study the situation was driven by repeated train delays and reports indicating the need for track improvements.
- b. Only counting the benefits to the state of Maryland, the benefit/cost ratio was shown to be 0.7. By including national benefits that accrued to Amtrak and to shippers outside of the Maryland environment, the benefit/cost ratio rose to 1.1. The inclusion of supply chain benefits increased the benefit/cost ratio to 1.6 (see Figure 6). So, assuming the financial results were in or near a reasonable range, the chances of acceptance would be more than twice as good when counting supply chain benefits.



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Figure 4: Rail Freight Case Study Results

Stakeholder	Maryland Benefits	National Benefits	Total National Benefits
	Only (No Supply Chain Benefits Included)	(Excluding Full Highway User Benefits And Supply Chain Benefits)	
Freight Rail Operators	\$270	\$270	\$270
Shipper Costs	\$1,052	\$1,656	\$1,656
Amtrak	\$176	\$626	\$626
Highway Benefits	\$565		\$874
Supply Chain Benefits			\$1,303
Total Benefits	\$2,063	\$2,552	\$4,729
Total Costs	\$3,046	\$3,046	\$3,046
Benefits/Cost Ratio	0.7	0.8	1.6

- c. The same principles apply to many transportation capital investments outside of the US. For example, two large investments that could serve as additional case studies of supply chain benefits would be the Madrid Calle 30 PFI in Spain and the Incheon Grand Bridge in South Korea.
 - i. Madrid’s Calle 30 orbital motorway is roughly an \$8b road project around the city of Madrid. The first phase consists of 16 separate projects, including the upgrade, construction, and improvement of 13 motorway junctions and access roads. It also includes the construction of 2 new three-lane tunnels, some 4,200 meters long and 15 meters wide. These tunnels will be bored by the largest tunnel boring machines ever built. Due to the project’s magnitude and breadth, many stakeholders will benefit from the construction, and supply chain benefits should be extensive.
 - ii. South Korea’s Incheon Grand Bridge, approximately a \$1.4 billion project, will span more than 10 kilometers between the new island-based international airport and Incheon City, southwest of Seoul. Somewhat in the same manner as Yangshan in China will dramatically change the patterns of freight movement in Shanghai, the Incheon Grand Bridge will benefit many shippers, carriers, and citizens. The supply chain benefits should be substantial and could be factored into the cost/benefit equation.

The potential impact on transportation capital programs nationwide

- 2. Based on case study analysis for the USDOT Freight Economic Guide, omitting supply chain benefits implies that government planners may be under-valuing the potential benefits of freight transportation investments by up to 38%. This is demonstrated in Figure 4 which is drawn from application of supply chain benefits analysis to a major freight rail investment in Baltimore. Assuming for a moment that approximately half the potential investment projects are similar to



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the case examined for this research and that 15 to 30% of projects that are currently rejected would be accepted if they had this additional amount of benefit accounted, that would result in funding about 23% more investment.

The implication is that the country has been under-building by about 8% annually since about 1986, when supply chain management gained currency as a management movement and companies began actively managing their supply chains.

Figure 5: Incremental Projects that Would be Funded if Supply Chain Benefits Were Considered

Parameter	Value (Percent or Millions of US Dollars)
Supply chain benefits	\$ 135
Total benefits	\$ 352
Supply chain benefit as % of total benefits	38%
Second-order benefits, including supply chain	\$ 310
Total benefits	\$ 414
Total second order benefit as % of total benefits	75%
% of cases like Baltimore	50%
% of cases that are within 38% of having a net positive NPV	30%
% of cases that are within 75% of having a net positive NPV	60%
Percent more projects that would be approved - low estimate	15%
Percent more projects that would be approved - high estimate	30%
Percent more projects that would be approved - average	23%

- Based on actual federal and state capital expenditures for all modes in 2004, an additional \$7 billion would be spent annually.³ Retrospectively, the cumulative value of an 8% under-investment for 23 years would have resulted in several times the capital expenditure that actually occurred during that period.

Figure 6: Hypothetical Impact on the US Transportation Budget

³ Assumes that the average project budget is expended over a three-year time horizon, and that the transportation budget consists of 47% capital expenditure and 53% operating and maintenance expenditure, which was the case with the highway budget in 2006.



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Column1	Value (Percent or Billions of US Dollars)
Transportation Capital Expenditures, 2004 (\$US billions)	\$ 213
% Additional Projects that would be funded	23%
% of budget for capital projects (vs. operating expenses)	47%
Average years duration of capital projects	3
Implied additional yearly budget (\$US millions)	7,454
Percent additional transportation funding	3.5%

What needs to happen

4. Governments should change the way that major freight projects are evaluated to ensure the creation of these supply chain benefits. They should:
 - a. Identify and review high-profile investments that are especially likely to generate supply chain benefits. For example, the recent National Surface Transportation Policy and Revenue Commission (with strong private sector participation) recommended the creation of a program of investment entitled “Freight Transportation: A Program to Enhance U.S. Global Competitiveness”. That Commission report recommended a substantial national commitment to transportation investment of “at least \$225 billion annually from all sources for the next 50 years” which, *if supply chain benefits were the only gap to be addressed*, would effectively integrate supply chain benefits into US transportation funding.
 - b. Apply the benefit calculation method proposed in “Guide to Quantifying the Economic Impacts of Federal Investments in Large-Scale Freight Transportation Projects.” As described in that Guide, the magnitude of supply chain benefits of freight projects will vary based on the industry mix of shippers and receivers impacted by the improvement (origin and destination of trips) as different industries have different magnitudes of short-term and long-term response.
 - c. Develop the methodologies for sharing the costs and benefits, including funding the research needed to establish a framework for splitting the costs and benefits among affected parties. This last step will require a subordinate, but critical, piece of research: an acceptable method for quantifying the international trade benefits of large-scale infrastructure projects will be essential to equitably allocating supply chain costs and benefits.
5. Carriers and shippers should use industry associations to provide input to the government on how to prioritize, evaluate, and approach costs and benefits when dealing with public-private partnerships that involve multiple parties.
6. Academics should teach public private partnerships in Finance and supply chain courses, and in pursuing grants for research in the area to accelerate the resolution of this critical issue.

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7. The issue of shared benefits and costs will not go away. It will increase in depth and breadth as international trade increases and an increasing number of gateways needs to be built and expanded. Supply chain benefits are at the center of that issue, and acknowledging them will be the first step on the way toward an important new approach to transportation infrastructure management.

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