Owen Kehoe [9624492]
CEE591 Final Paper
12-8-2003

Economics of Truck and Rail Freight Transportation

A look at public and external costs and the truck-rail modal split

Introduction/purpose

This report provides an analysis of the costs involved with rail and truck freight transportation. The focus will be costs that are currently not reflected in the rates, or private costs, that shippers "see" when deciding to transport freight over one of the two modes. Recommendations will be formulated for internalizing these external costs and creating more equitable and more efficient freight transport policies. The impacts on demand and truck-rail modal splits from internalizing costs will also be examined.

Background

When freight is transported over land routes, there is often the choice of shipping by either truck or by rail. North America has both an extensive highway network and an extensive rail network; these networks closely parallel each other and are often both viable choices for freight transport for most origins and destinations within the continent. Many factors will come into play with the decision to use truck or rail for a particular shipment, but most of these factors can be aggregated and analyzed with a cost figure. There are different types of costs associated with freight transportation, which can be categorized as private, public and external costs. These types of costs will be discussed in detail in a later section.

Cost ultimately drives demand and modal split. If rates go up for one mode, there will be less demand for that mode and some demand will shift to other modes. Demand and modal splits have significant impacts for planning and operation of transport facilities.

Competitive Shipments

There are many different types of trucks and trains used to carry various kinds of cargo; the costs can vary significantly between the different types. Several authors have looked in detail at costs associated with trucks and trains and broken down the costs separately by type of vehicles and rolling stock. When considering marginal demand and modal split, the most relevant kinds of shipments are those that are most competitive between rail and truck modes. These include long-haul shipments greater than 500 miles, which weigh between 50,000 and 80,000 pounds (the road-legal limit in many states). Special kinds of cargo like coal and short-haul deliveries are of less interest because they are generally not economically transferable between truck and rail modes, and would not be expected to shift modes except under an extreme price change.

Private Costs

In economic terms, private costs are the costs that are borne directly by the user. Private costs are primarily what drive behavior in a market; in this case, the price of transporting goods by truck and rail is the primary factor influencing demand for these two modes. In an ideal market situation, the private costs equal the cost to society of providing the service. A theoretically ideal market results in a price-demand equilibrium where all of the service consumed results in a net benefit to society. However, real-world markets have inherent inequities that distort the balance of costs and benefits, especially in the realm of transportation.

Truck private costs

The cost of labor represents the highest cost to the U.S. trucking industry, representing 35% of total operating costs. Fuel is the second largest cost at 15%. For the Canadian trucking industry, the shares are 27% and 21%, respectively [Transport Canada]. Tractor power units cost in the range of $90,000 - $100,000 to purchase, and the purchase cost of trailers ranges from $30,000 for a simple 2-axle trailer up to $60,000 for an eight-axle train van. [Transport Canada] For this relatively low initial cost, an individual or firm can begin hauling their first truckload of freight.

The cost to operate a truck, considering all private costs, varies by the distance traveled, ranging from 21.17 cents per ton-mile for shipments of less than 250 mile to 7.69 cents per ton-mile for shipments of over 500 miles. [Forkenbrock, Truck] The latter figure is most relevant to truck-rail competitive shipments.

Rail Private Costs

Operating costs for rail vary considerably depending the commodity shipped and the type of train. Construction of rail facilities is a capital-intensive process. For example the rail itself costs $267, 000 per mile and the newer concrete ties run $190 apiece [Harrison]. But once rail facilities are built or upgraded, rail is able to transport freight at a much lower line-haul cost than trucks. Similarly, the process of switching trains, operating locomotives and maintaining a schedule is a labor intensive process, but the addition of a few more units of cargo into the system results in minimal additional costs.

According to the American Association of Railroads, the aggregated cost for all rail shipments was 2.24 cents per ton-mile in 2001, and was 2.68 cents per ton-mile for intermodal (piggyback) shipments [AAR]. The intermodal scenario in this case is of interest because it consists of semi-trailers that are carried on special flatbed rail cars, carrying cargo that is most easily transferable between truck and rail modes.

Public Costs

Public costs are costs that are borne by the public through taxes or other fixed-rate fees, and are used to provide an indirect but essential part of a particular good or service. Individuals or companies pay the same public costs no matter what quantity of goods or services they consume. Public costs are traditionally used in cases where it is difficult to establish a user fee system, where the benefits are uniform across society, or when the marginal cost to provide additional units of service is low. Subsidies are a form of a public cost, used when market forces alone are not strong enough to establish a beneficial service. Highway construction and maintenance are obvious examples of public costs.

Truck Public Costs

The public cost most directly attributable to truck freight transportation is pavement rehabilitation. Heavy vehicles in excess of 18,000 pounds cause nearly all of the pavement damage on the nation's highways [WSDOT, pavement]. On interstate highways the vast majority of these heavy vehicles are trucks carrying freight. According to the 1997 Federal Highway Cost Allocation Study undertaken by the Federal Highway Administration (amended in 2000), the federal government expended over $7.9 billion on pavement rehabilitation alone in year 2000. [FHWA 2000] Additional state and local funds, not included in the figures above, were also used for pavement rehabilitation. Road user fees are charged to trucks operating on state highways, in order to recoup some of the rehabilitation cost . In Washington State, these fees range from $.02 to $.09 per ton-mile, depending on the weight of the truck (heavier trucks are charged more per ton-mile) [WSDOT, Permit].

The FHWA study looked at a variety of vehicle classifications and evaluated the impacts of each class on the national highway system. The study concluded that, under current road pricing schemes, heavy trucks underpay relative to their impact on highways, while light trucks overpay for their use of the highway system. With all trucks aggregated together, the study found that trucks underpay their impact to the highway system at a rate of 0.25 cents per ton-mile. Heavier trucks would be most likely to shift to or from rail, so the marginal benefit of a shift to rail freight would likely be greater than this figure.

Rail Public costs

Rail transportation does not incur large public costs, particularly in freight transportation. Railroads own most of the tracks that they operate on and are responsible for maintenance and upgrades of these tracks. Therefore construction, maintenance, and other track improvements would be considered private costs. State and federal grants are available for rail companies to use for infrastructure investment, however the majority of these funds are dedicated to rail grade crossing improvements or passenger rail service. [WSDOT, Rail] Because public investment in freight rail is small compared to other public investments, it is assumed that rail has zero public cost.

External Costs

External costs generally include environmental costs imposed on non-users. Air pollution, noise, and the cost to society of accidents are typically categorized as external costs. Quantifying external costs can be a difficult and highly subjective task, but researchers have developed some clever techniques for assigning dollar values to external impacts.

Truck External Costs

A 1999 study by Forkenbrock evaluated the external costs that trucks impose on the environment as they are used to transport freight. These cost categories included accidents, air pollution, greenhouse gas emissions, and also included the highway user charge underpayment developed in the FHWA study, mentioned earlier.

Accident costs were evaluated by looking at prices people will pay for risk reduction versus what they will pay for other goods, then applying the prices to accident histories to determine a total truck accident cost to society. Liability settlement compensation paid by truck companies was subtracted from this cost figure because this would represent a private, non-externalized cost resulting from accidents.

Pollution costs were measured in terms of impacts to human health, medical expenses, and the damage to crops and animals resulting from the pollution emitted by trucks. The cost of greenhouse gas emission was measured in terms of the mitigation measures humans need to employ to respond rising sea levels, reduced freshwater supplies, crop damage, and other impacts of climate change. Many controversial assumptions need to be made for these particular cost assessments, however Forkenbrock took a conservative approach with these assumptions.

Noise impacts are measured by comparing differences in real-estate values near highways with varying amounts of ADT and heavy-vehicle compositions, with a baseline of real-estate prices not near major highways.

These costs when taken together and combined with the public cost underpayment figure, result in an average external marginal cost of 1.11 cents per ton-mile. This figure represents a weighted average of the various truck combinations in use.

Rail External Costs

Another study by Forkenbrock similarly analyzed the external costs of rail transport. The cost of accidents, air pollution, noise, and greenhouse gas emission were quantified in a fashion similar to the truck external cost analysis. This study further identified that different kinds of trains are in use with different kinds of costs associated their operations. Four different train scenarios were analyzed, including heavy unit train, mixed freight train, intermodal (piggyback) train and double-stack container train. The intermodal scenario of interest for competitive shipments has an external marginal cost of 0.25 cents per ton-mile. The other three scenarios had similar external costs, all within 0.01 cent of the intermodal figure.

Comparison of Costs

A direct comparison of the public and external costs can be difficult because of the wide variety of vehicles, operating environments, different types of freight and hauling distances. Also, the methods used to measure these costs vary widely and can often result in very different numbers. The costs discussed previously were analyzed both in aggregate and in the context of shipments that are competitive between the two modes, depending on the data used in the analyses. Similar methodologies were employed to quantify both truck and rail costs for a valid comparison.
Table 1 summarizes these costs.

Table 1: Summary of costs for truck-rail competitive freight shipments (cents per ton-mile)

Mode	Private Cost	Public Cost	External Cost	Total non-private costs	%
Truck	7.69	0.25	0.86	1.11	14.4%
Rail	2.68	0.00	0.25	0.25	9.3%

These results show that truck freight transportation imposes a higher cost to society than rail transportation, considering the non-private costs.

Equating the Costs

Public policy can be used to transfer the external costs to a private cost to make the market operate more efficiently in the public interest. Road-fees for recouping a

portion of the public cost component of trucks are already well established, but the rates should be reformed to more accurately reflect actual impacts. User fees can be implemented to both trucks and rail to transfer the external cost to the user, using the proceeds to mitigate the specific impacts.

Developing a rate structure that is equitable to all users can be politically challenging, particularly due to the subjective nature of quantifying external costs. Based on the assumptions of this analysis, trucks should be charged a user fee of 1.11 cents per ton-mile (a 14.4% increase) and intermodal rail should be charged 0.25 cents per ton-mile (a 9.3% increase).

Impacts to Demand and Modal Split

The previous section showed that both trucks and rail do not fully pay the costs that they impose on society, with trucks having a greater externalized cost. What would happen to demand and the truck-rail modal split if user fees were established to internalize these costs?

Economists use the concept of elasticity to measure how a change in price will affect a change in demand for a good or service. Similarly, the cross-price elasticity is used to determine how a price change of one particular good will affect demand for a substitute or complimentary good. Elasticities are measured by comparing changes in demand over real-world changes in price, using the following equation:

$$e_{xy} = \frac{percent\ change\ in\ quantity\ of\ x}{percent\ change\ in\ price\ of\ y}$$

A 2002 study by Dewey reported a range of cross-elasticities for trucks and rail for various types of commodities. Overall, the elasticities are similar in magnitude across the various commodities. These elasticities, aggregated for general freight, are shown in Table 2 and are used in Table 3 to calculate the demand and modal split changes that would be expected if rates were increased to compensate for the underpayment costs derived from Table 1.

Table 2: Cross Price Elasticities for Truck and Rail

	Rail Price	Truck Price
Rail Demand	-0.7	0.1
Truck Demand	0.15	-1.0

Source: Dewey Table 6

Table 3: Changes in demand and mode split resulting from cost increases

Mode	Change in Price	Change in Demand	Mode Shift (from other mode)	Net change
Truck	14.4%	-14%	1.4%	-13.0%
Rail	9.3%	-7%	1.4%	-5.1%
			Total change:	-18.1%

These results show that if shippers had to pay the full societal cost of transportation, as outlined in the previous section, there would be an expected 13% decrease in ton-miles carried by truck, 5% decrease in ton-miles carried by rail, and 18% of the existing freight would no longer be worthwhile to transport. In the long term, there would likely be an even greater shift to rail as intermodal facilities are improved and railroads capitalize on economies of scale to lower their private costs.

Such a large drop in freight demand may prove to be more harmful within a broader economic scope. Providing a subsidy in addition to the user fee could attain the same efficient modal split while preserving an adequate level of demand. Public funding for rail freight capital improvements would drive down the private cost of rail, increasing demand. This would be an efficient form of subsidy, due to the economies of scale inherent in rail.

Conclusions

When comparing the costs associated with truck and rail freight transportation, it is clear that trucks impose greater public and external costs than rail. Quantifying these costs based on existing research suggests that a user fee system is needed to internalize these external costs. An analysis using economic elasticities showed that the effect of internalizing costs would likely be a significant reduction in the volume of freight transported, evidence that a subsidy for rail freight many be needed. Although a new

pricing system would undoubtedly be controversial, it would result in a more efficient and equitable freight transportation system.

If such a user fee system were to be implemented, a comprehensive research effort would be needed to further refine the public and external costs. Costs would need to broken down by various vehicle classes and possibly different train types. Further research would also help build support and consensus on the establishment of a fair user fee system.

References

Association of American Railroads. *Falling Railroad Rates: Billions of Dollars in Shipper Savings.* July 2003. http://www.aar.org/GetFile.asp?File_ID=153

Dewey, James F., et al. *The Response of Railroad and Truck Freight Shipments to Optimal Excess Capacity Subsidies and Externality Taxes*. University of Florida Bureau of Economic and Business Research. September 30, 2002.

Federal Highway Administration. *1997 Federal Highway Cost Allocation Study - Final Report*, August 1997. U.S. Department of Transportation. http://www.fhwa.dot.gov/policy/hcas/final/index.htm

Federal Highway Administration. *Addendum to the 1997 Federal Highway Cost Allocation Study Final Report*. May 2000. U.S. Department of Transportation. http://www.fhwa.dot.gov/policy/hcas/addendum.htm

Forkenbrock, David J. *External costs of intercity truck freight transportation*. 1999, Public Policy Center, The University of Iowa, Iowa City, IA.

Forkenbrock, David J. *Comparison of external costs of rail and truck freight transportation*. 1999, Public Policy Center, The University of Iowa, Iowa City, IA.

Harrison, Rob. *Performance of Rail and Truck Modes Moving Texas Grain*. Center for Transportation Research. Presentation Notes.

Silberberg, Eugene. Principles of Microeconomics. 1995, Prentice Hall, Inc., New Jersey.

Transport Canada, *Operating Cost of Trucks 2000*. http://www.tc.gc.ca/pol/en/report/OperatingCost2000/contentsCost2000.htm (Note: Canadian currency converted to US dollars using conversion rate $1 CDN = $0.674 USD)

Washington State Department of Transportation, *Rail – Executive Summary*. 2002. http://www.wsdot.wa.gov/rail/plans/DTA/DTAexec_sum.cfm

Washington State Department of Transportation, *Washington State Permit and Fees*. 2003. http://www.wsdot.wa.gov/freight/mcs/WashingtonPermitFees.htm

Washington State Department of Transportation, *WSDOT Pavement Guide, Volume 2*., February 1995. http://www.wsdot.wa.gov/fasc/engineeringpublications/Manuals/Volume2.pdf