The Energy Crisis and Intermodal Competition

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This paper analyzes the effects of recent changes in the supply and price of energy on freight transport modes. This is accomplished by studies of the relative energy efficiency of the modes, the relative energy cost intensity of the modes, and the effects of government intervention. Relative modal energy efficiency is analyzed by comparing similar types of service. This approach goes beyond simple comparison of aggregate fuel efficiency data. The conclusion reached is that the relative efficiencies change for different types of service. Energy cost intensity is an important component of the effect of fuel price increases on relative modal competitiveness. Fuel costs are now approximately 55 percent of total waterway operating costs, 24 percent of total truck costs, and 12 percent of total rail costs. Therefore, as energy costs increase, barge costs increase the most, and rail costs increase the least. Government control of the price and supply of energy can prevent railroads from realizing cost and efficiency advantages. Also, the regulatory system creates a lag in railroad recovery of rising fuel costs. The main implication here is that increasing energy costs will improve the competitive position of the rail industry. However, such an improvement may be circumvented by government intervention in the energy market.

This paper evaluates the effect of changes in the supply and cost of energy on intermodal competition. First, there is a review of the relative energy efficiency of the freight modes in which the emphasis is on comparing similar types of service. Second, the effects of energy price increases on the relative cost competitiveness of the freight modes are determined. Finally, the effect of government action on the energy market will be discussed.

MODAL ENERGY EFFICIENCY

The issue of relative modal fuel efficiency arises together with the focus on energy problems. Although numerous studies and reports have focused on fuel efficiency, most simply compare aggregate rail shipments with aggregate truck and barge shipments. These comparisons may result in misleading conclusions because they do not attempt to compare the fuel efficiency of similar types of service.

Truck Energy Efficiency

Truck fuel economy varies; it may depend on type and size of engine, cargo weight, vehicle speed, and the presence of various fuel-saving devices such as gear governors and wind deflectors. Actual truck fuel efficiency is usually in the range of 4-8 miles/gal.

A field survey of rail-competitive intercity truck movements by the National Motor Transport Data Base (NMTDB) of the Transportation Research and Mar-

keting Company in Salt Lake City provided data on truck fuel economy for this analysis. The survey consisted of 28 000 interviews with tractor-trailer drivers taken at 20 locations around the country from 1977 to July 1979. Survey data were used in two ways. First, the driver's actual reported fuel efficiency was tabulated. Second, empty mileage for various types of truck operations was calculated. The amount of empty mileage that a particular freight haul causes is vital in computing the energy cost of that particular move or class of movement.

Table 1 presents a detailed breakdown of the effect of empty mileage and tonnage on fuel efficiency. The table shows that fuel efficiency increases as average tonnage increases and as empty mileage decreases. Fuel efficiency was determined from statements by drivers in the NMTDB interviews. [In the table, the following assumptions were made: (a) an empty truck averages 6 miles/gal; (b) a 15-ton truck averages 5 miles/gal; (c) a 20-ton truck averages 4.75 miles/gal; (d) a 25-ton truck averages 4.5 miles/gal; and (e) the price of fuel is 90¢/gal (1).]

Rail Energy Efficiency

Rail fuel economies are often presented as an aggregate all-rail figure. However, as shown in Table 2, fuel economies for rail differ widely among types of service (2-5). For instance, Table 2 shows that unit trains can be up to nine times as fuel efficient as can local trains. The figure of 207 ton-miles/gal for all types of service is an average of the extremes of high-efficiency unit-train service and low-efficiency local service.

Barge Fuel Efficiency

Only one type of barge service is appropriate for comparison with rail. Most barge hauls are bulk movements that essentially compete with unit-train service. The barge fuel-efficiency figure is approximately 280 net ton-miles/gal (4). This figure accounts for empty mileage but not for barge circuity.

Energy Efficiency Comparison

A comparison of energy efficiency for similar services by the different modes can be made by using

Table 1. Truck energy efficiency.

Loaded Miles (%)	15-Ton Truck			20-Ton Truck			25-Ton Truck		
	Fuel Cost per Revenue Mile (cents)	Fuel Cost per Net Ton-Mile (cents)	Net Ton-Miles per Gallon	Fuel Cost per Revenue Mile (cents)	Fuel Cost per Net Ton-Mile (cents)	Net Ton-Miles per Gallon	Fuel Cost per Revenue Mile (cents)	Fuel Cost per Net Ton-Mile (cents)	Net Ton-Miles per Gallon
50	33.0	2.2	41	34.6	1.7	52	35.3	1.4	64
60	28.2	1.9	48	29.0	1.5	62	30.0	1.2	75
70	24.6	1.6	55	25.4	1.3	71	26.5	1.1	85
80	21.8	1.5	62	22.8	1.1	79	23.8	0.9	95
83[a]	21.2	1.4	64	22.0	1.1	82	23.0	0.9	98
90	19.5	1.3	69	20.6	1.0	87	21.5	0.8	105
100	18.0	1.2	75	19.0	0.9	95	19.8	0.8	114

[a]Base case.

Table 2. Rail energy efficiency.

Service Type	Average Tons per Car	Loaded Miles (%)	Net Ton-Miles per Gallon
Unit train	100	50	350
Carload	45	60	198
Long-haul TOFC	30	75	172
Short-haul TOFC	40	65	97
Local	45	55	40
All types	53	57	207

Note: Data on net ton-miles per gallon were obtained from the following sources: unit-train, carload, and short-haul TOFC from U.S. Department of Commerce study (4); long-haul TOFC from DOT report (5, p. 60), although the Atchison, Topeka, and Santa Fe Railway Company Ten-Pack equipment increases this by 15 percent; local from DOT report (5); and all types from AAR yearbook (2).

Table 3. Relative energy efficiency: rail versus truck.

Type of Service	Net Tons per Vehicle	Loaded Miles[a] (%)	Net Ton-Miles per Gallon	Energy Efficiency: Rail to Truck[b]
Unit train				4.4:1
Train	100	50	350	
Truck	25	50	69	
Rail carload				2.2:1
Train	45	60	198	
Truck	20	80	77	
Long-haul TOFC				2.3:1
Train	30	75	172	
Truck	15	85	64	
Short-haul TOFC				1.6:1
Train	40	65	97	
Truck	15	70	54	
Local				0.6:1
Train	45	55	40	
Truck	20	60	61	

[a] These are typical for the service types mentioned.
[b] Adjusted for rail circuity, 1.17 percent of truck (4, 6).

Table 4. Fuel costs as a percentage of total truck, rail, and barge revenue.

Item	July 1978	January 1979	July 1979	July 1980 (estimate)
Truck				
Price of diesel fuel per gallon ($)	0.55	0.65	0.90	1.50
Fuel cost per revenue mile ($)	0.13	0.15	0.21	0.35
Revenue per running mile ($)	1.01	1.08	1.16	1.38
Fuel cost to total revenue (%)	13	14	18	25
Rail[a]				
Price of diesel fuel per gallon ($)	0.36	0.40	0.64	1.20
Fuel cost to total revenue (%)	7.5	7.9	10.2	16.2
Barge[b]				
Price of diesel fuel per gallon ($)	0.38	0.43	0.80	1.25
Fuel cost to total revenue (%)	32	34	48	57

Note: These are percentages of revenue; the fuel costs as a percentage of costs would be higher.

[a] Figures for July 1978-July 1979 calculated from AAR data (2); they are averages for all types of service for all U.S. class 1 railroads.
[b] Figures obtained from various barge companies.

the data supplied in Tables 1-3. Five energy efficiency ratios for different types of rail and truck service are presented in Table 3. The rail statistics were obtained from the same sources used in Table 2 (2-5), and the truck statistics were obtained by using the NMTDB field survey to get typical loaded/empty ratios for the different types of truck service. [Inland waterway barge statistics, determined from a 1974 U.S. Department of Commerce study (4), showed 277 net ton-miles/gal and an energy efficiency ratio for rail to barge of 1.5:1. This figure was adjusted for barge circuity, which was 1.60 percent of rail (6,7).] The tons per vehicle and the percentage of loaded miles assumed for each case were used to calculate the net ton-miles per gallon achieved by each of the modes in the various types of service. The efficiency ratios are based on net ton-miles per gallon adjusted for the circuity factors involved when modal comparisons are made. The ratios show the efficiency relationships between modes when average tonnage, loaded-mileage percentage, actual engineering efficiency, and circuity are taken into account.

Several points can be made about the ratios shown in Table 3. First, the data show that barge movements are sometimes not as energy efficient as the unit-train rail movements with which they compete. Also, it can be seen that long-haul unit-train service has the greatest energy advantage over truck service, whereas some local rail service is not as energy efficient as trucks that perform the same type of service.

The main point of the analysis is that service type is extremely important when energy efficiency

is evaluated. Simple statements that rail service is more energy efficient than truck service or that barges are more energy efficient than railroads are misleading. Relative modal energy efficiencies can vary widely depending on what kind of transportation service is being analyzed.

The implications of the efficiency comparison are these:

1. Loss of energy efficiency due to modal shift is an invalid argument against branch-line abandonment.
2. When used for the same type of service, barge movements are sometimes not as fuel efficient as are rail movements.
3. Rail movements could become even more relatively efficient if rail empty mileage were reduced. Usually, rail movements have more empty miles than do truck movements for comparable services.

ENERGY COSTS

In considering intermodal competition, the important factor about relative energy efficiency is how these efficiencies affect the relative energy costs for the different modes. As energy costs rise, total costs are affected differently depending on the energy cost intensity of each mode. Fuel efficiency alone is only one element of a carrier's total cost structure. The mode with the highest percentage of energy costs out of total costs will be that most affected by energy cost increases, regardless of relative fuel efficiency. A comparison of fuel costs as a percentage of total revenue for truck, rail, and barge operations from July 1978 to July 1980 is shown in Table 4.

Truck Fuel Costs

For the purpose of this analysis, only intercity rail-competitive trucks will be examined. This is an important distinction because the structures of fuel costs are somewhat different for the various types of trucking operations. Specifically, the fuel costs of the shorter-haul less-than-truckload (LTL) trucking operations make up a lower percentage of the total costs than do those of the truckload operations.

In 1978, fuel costs were 5-7 percent of revenue for some of the major regular-route common-carriage

Table 5. Effects of fuel price increases.

	July 1979		July 1980 (estimate)	
Mode	Fuel Cost as Percentage of Total Costs (%)	Increase in Total Costs as Result of 50% Increase in Fuel Price (%)	Fuel Cost as Percentage of Total Costs (%)	Increase in Total Costs as Result of 50% Increase in Fuel Price (%)
Rail	12	6	18	9
Truck	24	12	32	16
Barge	54	27	66	33

Note: The analysis holds nonfuel costs constant; percentage figures are calculated from revenue percentages in Table 4.

trucking companies involved primarily in LTL terminal-to-terminal operations. By comparison, fuel costs were approximately 13 percent (see Table 4) of revenue for owner-operators involved in long-haul intercity trucking. The difference is primarily due to the fact that the LTL operations have other, substantially higher nonfuel costs, for example, labor, terminals, and local pickup and delivery. The fuel cost per revenue mile and revenue per running mile (calculated from actual NMTDB data) are given in Table 4 for truckload trucking operations (the price for July 1980 assumes that a 10 percent increase in nonfuel costs is passed on in rate increases).

This analysis concentrates on truckload trucking operations because this is the type of trucking service that competes most with other modes. The analysis assumes that the average fuel economy is 5 miles/gal when the truck is loaded and 6 miles/gal when it is empty. In Table 4, fuel cost as a percentage of truck revenue is given for the standard case of an owner-operator involved in truckload service for July 1978 to July 1980. Between July 1978 and July 1979, the percentage of fuel cost to total revenue increased from 13 to 18.

Rail Fuel Costs

Between July 1978 and July 1979, the average price paid by U.S. railroads for a gallon of diesel fuel increased from 36¢/gal to 64¢/gal (a 78 percent increase). In July 1978, fuel cost was 7.5 percent (on an industrywide basis) of total rail revenue. (Some railroad fuel costs were as low as 6 percent and others as high as 8.5 percent of revenue.) The 78 percent increase in the price of fuel in one year resulted in an increase in rail fuel costs to 10.2 percent of total rail revenue. This new percentage accounts for the changes in nonfuel costs (which the analysis assumes increased 10 percent from July 1978 to July 1979). Rail fuel costs are shown to be as high as 16 percent of rail revenue by July 1980.

Barge Fuel Costs

Historically, barge companies have paid a few cents more per gallon for fuel than have the railroads, although fuel prices for barges vary greatly. Long-term fuel contracts are relatively uncommon in the barge industry, and railroads get a slightly better price due to volume buying and longer contracts.

During the summer of 1978, when railroads were paying 36¢/gal for fuel, barges were paying an average of 38¢/gal. At that time, fuel costs were approximately 32 percent of barge revenue. One year later, in July 1979, barges were paying approximately 80¢/gal.

By July 1979, the difference between the average price paid for fuel by barges and railroads had increased from 2¢ to approximately 16¢. This was because barge operators purchased a larger percentage of their fuel in small quantities at one time (spot market) than did the railroads during this period. Recently, spot-market prices have been very much above the standard contract prices.

At 80¢/gal (the July 1979 price), fuel costs paid by the barges made up 48 percent of their revenue. (This calculation assumes that nonfuel costs rise at a rate of 10 percent per annum.) If one assumes that fuel prices will continue to rise at this rate, by July 1980, fuel costs will be almost 57 percent of barge revenue. It is apparent that energy cost increases affect barge costs more than they do those of the other modes. This is due to the fact that barges are so much more fuel cost intensive than the other modes.

Energy Cost Comparisons

By using the calculations made so far, a comparison of the fuel costs of the different freight modes can be made. Table 5 shows how fuel price increases affect transport costs. The first case shows how transport costs will increase if fuel costs increase 50 percent above July 1979 levels. The second case shows the effect to be expected if fuel costs increase in 1980 to the levels forecast in this paper.

The analysis shows that the changing energy situation may significantly affect the cost competition between modes, especially between rail and barge movements. The era of inexpensive energy is over, and any mode that is energy intensive will become less competitive if energy costs continue to increase at a vastly greater rate than the costs of other sectors of the economy.

Supply of Energy

All three freight modes use middle-distillate fuel for most of their intercity freight movements. Middle distillates have been in especially short supply (when compared with other petroleum products) during the recent fuel shortage. Almost all users of middle distillates could be considered essential users to some extent. Because of the relatively inelastic demand (compared with other petroleum products) and because retail prices are not controlled, the recent shortage of middle distillates caused large increases in the price of this type of fuel.

As of January 1980, middle-distillate stocks were low for that time of year. Shortages are forecast for the winter of 1980. The severity of the shortages will depend on the weather, conservation efforts, and the true level of secondary and tertiary storage of home-heating oil (which is not now known). It is not unreasonable to expect conditions to occur that will result in severe shortages of middle distillates throughout 1981 and, with these shortages, still higher prices.

EFFECTS OF GOVERNMENT INTERVENTION

Since middle distillates are used primarily by essential users, any severe shortages in the middle-distillate market might result in government intervention. Such action might affect the relationship between energy price increases and competition between the modes. Some existing government actions and regulations are affecting this competition.

Government Economic Regulations

The government now interacts in the petroleum market by controlling the price of domestic crude oil, controlling the retail price of gasoline, and forcing reallocation of crude and retail supplies. There now exists the legislative mandate for many more avenues of intervention by the government. Among

these are (a) government allocation of all petroleum products in times of shortage (e.g., U.S. Department of Energy Special Rule 9), (b) government mandate on refinery yields, and (c) import quotas on petroleum products. The legislature is now working on other plans for government intervention. Such plans include schemes to set aside allocations to heating-oil users of all the middle distillate that they claim they need.

The basic thrust behind all present and proposed government regulations of the middle-distillate market is the control of price and supply. These regulatory controls are essentially subject to political rather than economic considerations. Under these conditions, the relative competitiveness between modes will not reflect the true costs of the economic inputs of the modes. Diversion to a more fuel-efficient mode will not occur if prices and supplies are artificially controlled. It is clear that government energy policies have a strong impact on intermodal competition.

Interstate Commerce Commission Regulations

The regulatory actions of the Interstate Commerce Commission (ICC) have an impact on how the energy crisis affects the different freight modes. All regulated carriers experience regulatory lag in recovering fuel cost increases. Specifically, the railroads have experienced up to 150 days' lag over the past year. (In this case, "lag" is defined as the period between the time at which the cost increase occurs and the time at which the rate increase goes into efffect.) Although efforts are being made by the ICC to reduce the problems of regulatory lag, the shortest possible lag period may still be from 50 to 60 days. Overall, the U.S. railroads lost an estimated $250 million in unrecovered fuel cost increases during the past 10 months.

Trucking companies also have their problems with regulatory lag. Barge operations are only 8 percent regulated; thus the majority of barge rates are not subject to regulatory lag. The important point is that the lag times affect the freight modes to different degrees and, because of this, rapid fuel price increases will cause a greater short-term problem for the railroads than they will for trucks and barges. Rail rate increases are subject to lag, whereas most barge rate increases are not. The effect of lag on railroads is greater than it is on trucks. Specifically, trucks face less regulatory lag than do the railroads, for the following reasons:

1. ICC procedures measure spot prices for trucks but contract prices for railroads.
2. Truck rate increases are effective on 1 day's notice; the railroad increases require 10 days' notice.
3. Truck rate calculations are allowed to be more retroactive than are those for rail rate increases.
4. The ICC covers the expense of surveying and reporting trucking cost information, whereas the railroads must cover the expense of surveying and reporting rail cost information. These costs for paperwork and administration can be substantial.

The main point is that the uneven treatment by the ICC results in a substantial financial disadvantage for the railroads in the short run because they cannot recover their fuel costs as fast as can the truckers. This disadvantage results in financial loss to the railroads and somewhat negates any advantages that the railroads have from their fuel

efficiency and from their not being as energy cost intensive as other modes.

SUMMARY

The important points of this analysis with respect to relative modal energy efficiency are as follows:

1. It is important to compare similar types of service when looking at relative modal energy efficiency.
2. Rail is often the most fuel-efficient mode when similar services are compared.

With respect to the impact of energy costs, the important points are as follows:

1. Cost structure is important in assessing the impacts of energy price increases on relative transport costs.
2. Energy price increases affect barge costs the most because barges are so energy cost intensive. Rail costs are affected the least because rail is the mode that is the least energy cost intensive.

The main points with respect to energy, competition, and public policy are as follows:

1. Market reaction to increasing energy prices can be distorted by government interaction (e.g., price and supply controls).
2. Preferential treatment of truckers by the ICC results in short-term financial disadvantages for the railroads in times of rapidly increasing fuel prices.

If economic forces are allowed to work, cost considerations will naturally result in the appropriate switch to the more-efficient mode. The extent of the switch will reflect the true economic costs of energy and the other inputs on transportation costs. Appropriate modal choice is an important goal because, while energy conservation is important, it should not be maximized at the expense of all other economic considerations.

If energy cost goals are suboptimized (e.g., by the imposition of price controls), the cost advantage that railroads have with respect to energy will be negated. Under these conditions, it will be difficult for relative rail rates to decrease.

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