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RATE REGULATION AND FREIGHT TRAFFIC ALLOCATION - A REVIEW AND REVISION

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The current inflation and recent fuel shortage have focused attention on the allocative effects of regulatory policy. In particular, the Interstate Commerce Commission (ICC) has been criticized for inefficiencies arising under its control of entry, rates, and investment in the surface freight transportation industries, and alternative regulatory practices, emphasizing less agency control, have been suggested. The objective of this paper is to estimate the losses that arise in rail and truck transportation of manufactured goods because the rate structure does not coincide with the costs of providing service. The literature on costs and service of these modes will be examined and updated, and the magnitude of the loss will be developed from a reallocation of current rail-truck traffic in manufactures to the lower-cost carrier. Finally, a more general approach to the evaluation of alternative regulatory policies will be described.

The three studies that will be considered here employ costing procedures and traffic allocation methods that are representative of the literature dealing with the effect of rate regulation on choice of mode. In the earliest and most comprehensive work, Meyer and his associates examined transportation costs, market structures, and demand conditions in determining both an efficient modal distribution of freight traffic and a regulatory policy conducive to such an optimum.[1]

1. John Meyer, Merton Peck, John Stenason, and Charles Zwick, The Economics of Competition in the Transportation Industries (Cambridge: Harvard University Press, 1959), pp. 15-17.

In the process, motor carrier costs were computed from ICC formulas, and rail costs were estimated from regressions of expense categories on output and size variables. In addition, the rail costs were adjusted upward for the inventory costs of the slower transit time and larger minimum load required for rail shipments. For the rail and motor carriage of high-value manufactured goods, Meyer found that the railroads had "a narrow cost advantage at 100 miles, and a clear and increasing cost advantage for traffic moving over 200 miles", while 97 percent of large common carrier truck operations covered more than 100 miles.[2] In an article dealing exclusively with the efficiency of rate-regulated competition between rails and trucks, Harbeson computed costs for both modes from ICC regional cost figures and adjusted them to account for the Meyer inventory costs and a deficiency in highway user charges.[3] Specifically, the average-weight rail manufactures shipment was compared with the corresponding average truck shipment at various distances. Using census figures on traffic distribution, the total of the losses from carriage by the higher-cost mode at each distance was found to lie between $1.1 billion and $2.9 billion per year depending on the regional cost scales employed.[4] Finally, in a review of the failures of freight transport regulation and the probable effects of alternative policies, Friedlaender developed costs for several shipment sizes and determined the distances beyond which the railroads, with higher terminal and lower line-haul costs, were the more efficient carrier.[5] Again, ICC costs were modified by rail inventory charges

2. Ibid., p. 194.

3. Robert Harbeson, "Toward Better Resource Allocation in Transport," The Journal of Law and Economics, vol. 12, no. 2 (October 1969), pp. 321-338.

4. Ibid., p. 332.

5. Ann Friedlaender, The Dilemma of Freight Transport Regulation (Washington, D. C.: The Brookings Institution, 1969), p. 42.

and increased trucking user fees. A comparison of the estimated distances with modal distribution figures by size of shipment and length of haul revealed a misallocation in favor of motor carriers in all but the small-size, short-haul and large-size, long-haul traffic.[6] These results can best be compared by basing them on common data and cost considerations. The results of such a comparison will be reported after a review of the roots of the intermodal loss and an examination of the weaknesses of each study.

Several types of inefficiency induced by regulatory policy may be identified.[7] Intramodal losses represent increased costs for a particular mode's transportation services; empty backhauls and increased mileage caused by route and commodity restrictions on motor carriers are an example. Intermodal losses result from carriage by a higher-cost mode. Welfare losses arise from pricing above marginal cost. Distortions in other sectors are caused by transport pricing policies; these are illustrated by the location of processing plants near markets and cities because of high rates on manufactured goods vis-a-vis natural resource inputs. And productivity losses are the result of an overall negative impact on innovation in transport; the delay in the adoption of the unit train and current restrictions on intermodal coordination may be cited. Only the intermodal loss arising from the divergence of rates and costs for motor and rail carriage of manufactured products will be studied here.

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6. Ibid., p. 68.

7. This classification follows Thomas Moore, "The Feasibility of Deregulating Surface Freight Transportation," in Almarin Phillips (ed.), Competition and Regulation, Brookings Institution (forthcoming).

The rate structure for regulated freight is based on both cost and demand considerations. Under value-of-service pricing, high-value manufactured goods are shipped under a relatively high ton-mile freight rate compared to low-value bulk commodities. This rate system developed as a railroad profit-maximizing strategy and a government policy for the development of the West. It has since been supported by the ICC as a means of maintaining low rates on bulk commodities (agricultural and natural resource goods).[8]

Regulation in 1887 was directed against railroad price discrimination with respect to shippers and against the instability caused by railroad pricing and financial practices; it did not deal with discrimination by commodities or with the basic problem of monopoly power. The railroads accepted regulation because it stabilized the rate structure while leaving value-of-service pricing intact. The existence of competing carriers and alternative suppliers and the importance of freight rates in market prices produced transportation demands that were inelastic for industrial goods and elastic for bulk commodities. Therefore, high rates on the former and low rates on the latter were more profitable than relatively uniform, cost-based rates. At the same time this rate structure aided Western development. Low rates on bulk exports increased the settlers' market area, while high rates on manufactured imports speeded the development of Western industry.

The efficacy of value-of-service pricing in meeting these goals depended crucially on the existence of excess capacity and the specified market conditions. Thus, railroad pressure for modification of the rate structure developed as rail traffic increased and then as increased carrier competition increased transport demand elasticities. Traffic growth brought about a decline in overcapacity that afforded the railroads the opportunity to reduce discrimination among commodity

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8. Friedlaender, op. cit., p. 26.

rates. Also, an imbalance in cross-country movements caused a shortage of capacity for agricultural shipments that exerted upward pressure on bulk rates. But the ICC and Congress continued to hold bulk rates down and reaffirm value-of-service pricing in order to protect depressed agricultural areas. However, motor carrier competition began to draw the lucrative manufactures traffic from the rails because trucking costs and rates were below regulated rail freight rates, even though rail costs were likely less than motor costs on all but very short hauls. Faced with both chaotic economic conditions in the trucking industry (due primarily to excess capacity) and the railroads' loss of revenue, the Congress regulated motor carriers in 1935 but did exempt agricultural commodities from rate regulation. Trucking rates became based on rail rates, as much a matter of expediency as anything else. Water transport came under limited regulation in 1940 despite the fact that water carriers forced the railroads to retain low rates on competitive bulk traffic. But competition by the lower-cost barges could have forced the rails off competitive routes or forced compensating rail bulk rate increases wherever barge competition was not effective. So value-of-service pricing has enabled the railroads to maintain low rates on agricultural and resource goods but required the regulation of both the motor carriage that directly threatened the rails' profitable traffic in industrial products and the water competition that indirectly jeopardized low rail rates on noncompetitive bulk.[9]

Because the rate structure reflects demand conditions and noneconomic considerations[10] as well as cost of service, some misallocation of traffic between railroads and motor carriers is likely to exist. It is usually argued that motor transport is overutilized because regulation has replaced price competition with service competition, but it is dangerous to generalize. Indeed, the history cited above suggests that some rail traffic may be protected by artificially high motor rates. Basically, the direction and magnitude of the loss depend on the relationship between rates (which determine the current traffic distribution) and costs (which determine an efficient allocation) for both modes. The loss can be estimated by comparing transportation costs for both the current traffic distribution and a cost-based allocation. However, before this can be done, it is important to understand the costing and allocation procedures used here and in the various studies and to recognize the difficulties inherent in those procedures.

9. See Friedlaender's essay for a more detailed exposition of the development of regulation and the apparent motivation for ICC policy decisions. Ibid., pp. 7-27.

10. Such factors include the provision of common carrier service on low-density routes and the maintenance of carrier traffic shares.

The relevant carrier costs here are long-run marginal costs. While it may be argued that pricing of transport services would be based on fully-allocated or long-run average cost under carrier competition (deregulation), marginal cost pricing leads to a more efficient allocation of resources (neglecting second-best problems). Any deficit arising from the excess of average costs over marginal costs, particularly for the railroads, should be recouped from a lump-sum transfer rather than an arbitrary fixed distribution of the deficit over transport services. If it is determined that no practical regulatory mechanism (including the option of no agency control) would lead to marginal cost pricing then the intermodal losses developed here would have to be refigured under the expected pricing norms.

One of the problems in the estimation of transport costs for a hypothetical regulatory environment is that such costs have not been observed; this, however, could be handled by correcting the observed costs for the effect of regulatory reform. In the case of complete deregulation, cost functions could be altered to account for the removal of route and commodity restrictions on motor carriage, the stimulus to managerial incentives of a competitive atmosphere, the removal of disincentives to adopt innovations, and so on. These are difficult adjustments to make and will not be attempted here.

Both Harbeson and Friedlaender employed ICC figures in developing basic terminal and line-haul costs. In the current construction or rail freight service costs by the ICC, the variable expense or marginal cost per unit is determined for various categories of operating expense from a regression of the expense on the relevant output variable. Both variables are deflated by miles of road as a carrier size measure. These costs are then assigned or apportioned to the basic transportation services, e.g., line-haul and yard switching, and, on the basis of industry averages, are converted to terminal costs per carload and per ton and line-haul costs per car-mile and per net-ton-mile.[11]

Before 1970, the variable expenses were taken simply as a fixed percentage (derived in early studies) of total operating expenses and returns on road and equipment. The Meyer costing procedure, which is similar to the current ICC methods described above, therefore represented a significant departure when it was published in 1959. But there still exist differences between the ICC and Meyer costing procedures, the most important dealing with the specification of the

11. Actually, the ICC has derived from historical data a percentage variable for the various expense categories which is the quotient of marginal and average cost. For a given year, variable expenses are the product of the percent variable and the total of the expense category, and then marginal cost is the quotient of the variable expenses and the relevant output unit. Interstate Commerce Commission, Bureau of Accounts, Explanation of Rail Cost Finding Procedures and Principles Relating to the Use of Costs (Washington, D. C., 1963), pp. 91-94.

cost function and the apportionment of common costs to freight and passenger service. These will be considered below.

Many of the criticisms of transportation costing methods concern the homogeneity of the output unit and the extensive aggregation and averaging of cost and operations figures.[12] These, however, have been directed toward the need to cost specific movements for rate-making purposes and are less significant for the large-scale traffic allocation desired here. Nonetheless, certain weaknesses of the ICC costing procedure and Meyer's regression methods are relevant here. The ICC uses a percent variable figure in deriving the variable portion of each expense category that may be expressed as the elasticity of costs with respect to output or as the quotient of marginal and average cost.[13] For the curvilinear relationship between deflated cost and output that the ICC estimates, both marginal and average cost and,

12. For example, see George Wilson, Essays on Some Unsettled Questions in the Economics of Transportation (Bloomington: Indiana University, 1962).

13. The ICC estimates:

$$\left(\frac{E}{S}\right) = a + b\left(\frac{Q}{S}\right) + c\left(\frac{Q}{S}\right)^2 + \varepsilon$$

where:

E = expense S = size measure (miles of road)
Q = output ε = disturbance

and the percent variable is given by:

$$\left(b + 2c\left(\frac{\bar{Q}}{S}\right)\right) \Big/ \left(a/\left(\frac{\bar{Q}}{S}\right) + b + c\left(\frac{\bar{Q}}{S}\right)\right)$$

where: $\left(\frac{\bar{Q}}{S}\right)$ = average output per mile of road

Interstate Commerce Commission, Bureau of Accounts, Rail Carload Cost Scales by Territories for the Year 1970 (Washington, D. C., 1973), p. 172.

therefore, percent variable, will be a function of output; so it is crucial that an appropriate level of output be employed. Griliches has found that in 1958 the ICC produced an overall percent variable of 77.6 percent by giving equal weight to the cost conditions of large and small firms alike; but consideration of the costs of the industry as a whole (by giving equal weight to each ton-mile, i.e., by weighting individual carrier cost experience by ton-miles) yields a percent variable of 97.4 percent.[14] The report of an aggregate percent variable for 1970 of 76 percent suggests that the over-representation of small road conditions continues and that rail freight costs are underestimated.[15] This averaging probem is not a factor in the Meyer procedure because the regressions are linear in the output variables and because the marginal costs are used directly without conversion to a percent variable.[16]

The two approaches also involve different treatments of carrier size; the ICC deflates costs and outputs by miles of track, while Meyer includes a size measure as a separate independent variable. In Meyer's formulation the object is to distinguish between costs variable with plant size and costs representing nonoptimal resource

14. Zvi Griliches, "Railroad Cost Analysis," The Bell Journal of Economics and Management Science, vol. 3, no. 1 (Spring, 1972), p. 29.

15. Friedlaender has pointed out that the greater degree of excess capacity in the larger roads (indicated in several studies) will lead to an overestimate of the long-run marginal cost in a linear cross-section regression. The effect in the curvilinear form estimated by the ICC is unclear. Friedlaender, op. cit., p. 193.

16. Meyer estimated:

$$E = a + bQ + cS + \varepsilon$$

where the variables are equivalent to those in footnote 13. Meyer et. al., op. cit., p. 36.

combinations at low levels of output. The ICC procedure extracts marginal costs but combines the size and threshold effects. Also, Meyer's specification includes the relevant size variable only where it is significant, while the ICC uses miles of road as the size measure in all the expense category regressions. Griliches has pointed out that the ICC formulation has no particular efficiency properties[17] and argued that the size variable is irrelevant.[18] The effect of these misspecifications on the estimates of marginal cost in the two approaches is not clear.

Finally, the allocation of costs between freight and passenger service is treated in two different ways. The ICC assigns common costs in the same proportion as costs incurred solely by either service, while the Meyer procedure bases the separation on the variation of costs with volumes of the services. The latter is accomplished by including a separate measures of freight and passenger output in the regression and is more reliable than the more arbitrary ICC assumption.

In all three studies, basic terminal and line-haul costs were adjusted for the value of the service differentials between rail and motor carriage. The longer transit time for rail shipment represents

17. If the random error is assumed proportional to size, then deflation can stablize the error variance and improve estimator efficiency. For a linear form, the correct weighted least squares method minimizes

$$\Sigma\left(\frac{E}{S} - \frac{a}{S} - \frac{bQ}{S}\right)^2$$

while the ICC procedure treats

$$\Sigma\left(\frac{E}{S} - a - \frac{bQ}{S}\right)^2 .$$

Griliches, op. cit., pp. 32-33.

18. However, Griliches based this conclusion on regressions of total firm cost on firm output (gross ton-miles) for alternative specifications of the influence of size; but the size variable may be significant for some individual expense category regressions. Ibid., p. 32. Borts and Keeler have criticized the inclusion of the size variable on more theoretical grounds. See George Borts,"Statistical Cost Functions - Discussion," American Economic Review, vol. 48, no. 2 (May, 1958), pp. 235-238, and Theodore Keeler, "Railroad Costs, Returns to Scale, and Excess Capacity," Review of Economics and Statistics, vol. 56, no. 2 (May, 1974), pp. 201-208.

an inventory cost to the shipper relative to the trucking alternative. The time differential between rail and motor movements over particular distances may be developed from the different operating characteristics of the two modes and the cost of the rail delay evaluated on the basis of commodity value and a premium for interest, risk, and obsolescence.[19] A second inventory effect arises because of the difference in minimum loads required for the application of carload or truckload rates, corresponding to the different capacities of rail and truck transportation units. It is composed of a cost to rail users of holding and storing larger inventories than truck shippers, less the decreased ordering cost of rail shipment of a given annual volume.[20] The values of other

19. The time differential may be approximated by:

$$T = \left(\frac{mr}{20} - \frac{mt}{37.5}\right) + \left(.1\frac{mr}{20}\right) + \left(\frac{mr}{250}(6) - \frac{mt}{250}(3)\right) + \left(\frac{mr}{140}(8)\right) + 48$$

where: T = time in hours, mr = rail miles, mt = truck miles. The first term represents the difference in average speeds of 20 mph for rails and 37.5 mph for trucks; the second allows for the rail time spent on sidings enroute; the third represents the difference in time required for interchange at distances of 250 miles; the fourth is the rail time related to switching at intermediate terminals; and the last represents slower terminal handling at origin and destination. The cost of the difference in transit time is given by:

$$\text{Inventory cost (transit)} = \frac{Ci}{H} \times T$$

where: C = commodity value, i = interest premium, H = 8760 hours per year. The parameters of the first equation were taken from the more recent studies. For the basic formulation, see Meyer et. al., op. cit., pp. 192-193.

20. This inventory cost may be approximated by:

$$\left[\frac{Ci + K}{2Y}\right](Q_r - Q_t) + S\left(\frac{1}{Q_r} - \frac{1}{Q_t}\right)$$

where: C = commodity value, i = interest premium, K = annual storage cost, Y = annual shipment volume in tons, S = ordering charge, Q_r, Q_t = minimum economic loads for rails and trucks, respectively. The first term represents the working capital and storage cost of the larger inventory required for the larger and less frequent rail shipments; the second represents the additional ordering expense of the more frequent motor shipments. For the basic formulation, see Meyer et. al., op. cit., pp. 190-192.

service differentials (relating to dependability, equipment availability, loss and damage performance, and other service qualities) have not been developed adequately in the literature.[21] The superior performance of motor carriers with respect to the service qualities mentioned suggests, however, that rail costs are somewhat understated relative to trucking costs.

There is one other adjustment that can be made to account for service differences between the modes. While motor carriers normally provide complete pickup and delivery service on their through shipments, the railroads' terminal service is limited to spotting freight cars on industrial sidings. Meyer has shown that the expense of maintaining and operating a private siding may exceed the cost of motor pickup and delivery,[22] so it is not unreasonable to include truck pickup and delivery expense as a cost of door-to-door rail carriage.

Finally, a correction can be made for the deficiency in user-charge payments by intercity motor carriers, a cost otherwise borne by the community. Meyer found a small deficiency for diesel vehicles but chose not to modify motor costs because of the relatively insignificant effect of user charges on total truck costs and because of the unreliability of the correction. Friedlaender and Harbeson increased trucking costs on the basis of a highway cost allocation study by the Bureau of Public Roads in 1965 in which each class of vehicle was

21. A figure for the value of these other services differentials is reported in a study by the Charles River Associates (CRA). The value is developed from ordinal rankings of the importance of various factors (including time in transit to which Meyer's formula assigns a cost) to shippers replying to survey questions. The procedure of interpreting the rankings as particular cardinal measures of the monetary values of the factors and choosing a specific weighting for individual responses cannot, however, be justified. Charles River Associates, Inc., Competition Between Rail and Truck in Intercity Freight Transportation (Cambridge, 1969), pp. 30-33.

22. Meyer, op. cit., p. 189.

assessed a proportional share in each of the highway cost increments for which it could be held responsible. The recommended increase in motor carrier fees was 1.4 to 1.8 cents per vehicle-mile.[23]

At this point it is necessary to examine the means by which the costing procedures considered above have been used to evaluate the extent of the traffic misallocation between rails and trucks. In all three studies, rail and motor carrier costs determine an efficient allocation of transport resources that can be compared with the existing distribution.

Harbeson developed costs for a weighted average truckload of manufactured goods of 16.6 tons and a corresponding weighted average carload of 33.7 tons at distances conforming to the mileage blocks used in census figures on traffic distribution. Because no nationwide cost scale is reported for either mode, upper and lower limits were set on the expected cost differential by comparing first the highest regional motor cost scale and lowest regional rail cost scale and then the lowest motor scale and highest rail scale. With costs and traffic given at various distances for each mode, the savings of a shift to the lower-cost carrier was computed. It is important to note that an excess of motor carrier costs over rail costs at any mileage does not imply a shift of all the relevant traffic. Instead, the cost differential is an average over all shipments so that there will exist specific commodity movements for which the cost advantage is reversed.

The main difficulty here is one of interpretation. The implication of the problem formulation is that the relevant choice for the shipper is between a truck shipment of a certain size and a rail shipment of approximately twice the size. Certainly the choice of these weights is open to question, despite the fact that they are average

23. Friedlaender, op. cit., p. 38.

loads; but more importantly the analysis requires a change in the scheduling and operations of the shipper. At this stage in the analysis of rate deregulation, it seems more appropriate to shift traffic to the low-cost mode without altering other shipper decisions, especially since the inventory effects of differences in service are not well formulated. This is the procedure adopted in the Friedlaender book. There unit costs were calculated for various shipment sizes.[24] Because rail terminal costs are high and rail line-haul costs low relative to motor carriers for every shipment size, it is possible to calculate distances beyond which railroads are the more efficient carrier. Friedlaender used these distances in conjunction with census data to indicate the types of shipment likely to be moved by the higher-cost carrier. One of the problems, however, in making a more detailed examination of potential traffic shifts is that the ICC costs are less reliable when extrapolated to atypical movements, e.g., very small or large shipment sizes.

As described above, the Meyer study derives its rail cost estimates from the regressions of the various expense accounts on the relevant output and size variables. The marginal output costs obtained from the regressions were then converted, if necessary, to unit ton-mile costs on the basis of industry statistics, e.g., yard diesel minutes per gross ton-mile. Motor carrier costs were derived from

24. Friedlaender seriously overestimated motor carrier line-haul costs. In effect, she double-counted by calculating trucking line-haul cost from ICC reported figures for both line-haul cost per vehicle-mile and per hundredweight-mile; these, however, are regional averages calculated as the quotient of total variable line-haul cost and, first, vehicle-miles, and, then, hundredweight-miles. This error is implicit in the cost calculations. Friedlaender, op. cit., p. 39. The correct interpretation of the costs is given in Interstate Commerce Commission, Bureau of Accounts, Simplified Procedure for Determining Cost of Handling Freight by Motor Carriers (Washington, D. C., 1968), p. 4.

an ICC regional study. Both sets of costs applied to average or typical shipments. With these costs Meyer determined the distances for which each carrier was efficient and compared this cost-based allocation with the actual traffic distribution.[25] It is useful to note that Meyer's derivation and comparison of traffic allocations (as opposed to determination of costs) is similar to both Harbeson's and Friedlaender's procedures. Meyer and Harbeson computed costs for average size shipments while Meyer and Friedlaender used modal costs to find the lengths of haul for which each mode was the lower-cost carrier.

The details and results of an updating of the Harbeson and Friedlaender studies are given below. The Meyer work is excluded in what follows because not all the data required for a complete estimation of costs has been published[26]; the severity of this omission is, however, tempered by the fact that the method of evaluating the extent of the misallocation is represented in the two reported studies. All the results described in the next section must be viewed in the context of the difficulties and weaknesses involved in the costing and allocation procedures that appear in the literature.

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25. The CRA researchers extended the Meyer cost estimates and used traffic data to develop explicit figures for the potential traffic shift and resulting reduction in system transport costs. The analysis, however was perfomed in a rather careless manner -- parameters common to both inventory costs were updated in one but not the other and a simple calculation, from which a key result is obtained, appears to be incorrect. Charles River Associates, Inc., op. cit., pp. 20-29, 45.

26. For example, yard diesel switching hours is required for Meyer's regressions of yard expense but is not published on a road-by-road basis for 1970-71.

The Harbeson and Friedlaender studies may be compared by basing them on the same cost considerations and years of operation. In the revision that follows, basic terminal and line-haul expenses were obtained from ICC cost studies for 1970[27] and adjusted to account for user charge deficiencies[28] and service differentials related to time in transit,[29] minimum shipment sizes,[30] and pickup

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27. Interstate Commerce Commission, Bureau of Accounts, Rail Carload Cost Scales by Territories for the Year 1970, pp. 114-134, and Interstate Commerce Commission, Bureau of Accounts, Cost of Transporting Freight by Class I and Class II Motor Common Carriers of General Commodities by Regions or Territories for the Year 1970 (Washington, D. C., 1972), pp. 25-193.

28. Motor carrier costs were increased 1.8 cents per vehicle-mile. This figure was obtained by selecting 1.6 cents per vehicle-mile (the midpoint of the range suggested by Friedlaender and cited in the text above) as the relevant figure for 1965 and adjusting it to 1970 price levels with the wholesale price index for construction materials and components.

29. See footnote 19 for the formulation of this inventory effect. The cost was evaluated for:

$C = \$1,000$ per ton; $i = 15\%$ per annum

The value figure was derived from census figures on commodity volumes and from wholesale prices of individual commodities. The selection of representative goods for each census group reflected a bias toward over-estimation of the average value. See U. S. Census Bureau, 1967 Census of Transportation, Vol. III, Commodity Transportation Survey, Part 1, Shipper Groups (Washington, D. C., 1970) and Interstate Commerce Commission, Bureau of Transport Economics and Statistics, Freight Revenue and Wholesale Value at Destination of Commodities Transported by Class I Line-haul Railroads (Washington, D. C., 1961).

30. See footnote 20 for the formulation of this inventory effect. The cost was evaluated for:

$C = \$1,000$ per ton; $i = 15\%$ per annum; $K = \$100$ per ton per year; $S = \$10$ per order; $Y = 5,000$ tons per year; $Q_r = 25.6$ tons (Harbeson), 15-50 tons (Friedlaender); $Q_t = 12.2$ tons (Harbeson), 10 tons (Friedlaender).

The result was a small net charge against motor carriers for all but largest rail shipments, and in the interest of overstating the case for motor carriers, no adjustment of basic costs was made.

and delivery.[31] Losses were determined by comparing cost-based allocations with traffic distribution figures by length of haul or by size of shipment and length of haul for 1967.[32]

Harbeson's procedure will be considered first. Costs were estimated for average loads of 12.2 tons per vehicle for Class I inter-city common carriers and 25.6 tons per car for Class I railroads.[33] Motor carrier costs assumed a single-line movement with no intermediate transfer, while rail costs were based on shipment in a general service, unequipped boxcar in an average weight train. Costs were calculated for distances corresponding to the census mileage blocks.[34] The intermodal loss was determined by evaluating the savings at each distance of reallocating all traffic to the lower-cost mode and then

31. Pickup and delivery costs for the Eastern-Central territory in 1970 were used, with the assumption of a maximum motor carrier load of 30 tons. See text below for the importance of this assumption.

32. Distribution figures by length of haul and size of shipment were published only for the individual commodity classes, so the aggregate figures required here were prepared by the author. See U.S. Bureau of the Census, op. cit.

33. These figures were drawn from Interstate Commerce Commission, Transport Statistics in the United States, year ending Dec. 31, 1970, Part 1, Railroads, and Part 7, Motor Carriers (Washington, D.C. 1973). Although they represent averages for all commodity traffic, the figure for motor carriers should be accurate because manufactures account for more than 80% of trucking tonnage. Railroads, however, carry a much larger proportion of bulk commodities, so that the figure used is likely an overestimate of the average manufactures load. This error may be counteracted to a greater or lesser extent by the fact that the rail costs used apply to carload shipments and not all shipments.

34. An allowance for circuity was necessary because the census figures represent straight-line miles. Short-line or rate-making miles exceed straight-line miles by 24% and 21% for rails and trucks, respectively and, on average, actual miles exceed rate-making miles by 16% and 6%. Therefore, census mileages were increased by 44% for railroads and 28% for motor carriers.

summing the individual components. The steps and results of this computation are shown in Figure 1 for the lowest regional motor carrier costs and highest regional rail costs and in Figure 2 for the corresponding highest motor carrier and lowest rail cost scales.[35]

Friedlaender's analysis required costs for several specific shipment sizes. Motor carrier costs were based on weighted average single and interline movements in Eastern-Central territory and rail costs on average freight car costs[36] in an average weight train in Official territory.[37] Following Friedlaender no consolidation of small shipments was made, but her assumption of a 20-ton maximum load for motor vehicles was revised to a 30-ton limit.[38] Higher terminal costs and lower line-haul costs for rails relative to trucks at all shipment sizes indicated a rail cost advantage at the longer distances. Therefore, the costs were used to determine the distance beyond which

35. The lowest regional motor carrier costs were reported for the Southern (Intra) region for the first seven mileage blocks and the Southwest region for the remaining five; the highest rail costs appeared in the Mountain Pacific and Trans-territory for the first mileage block and in the New England region for all others. These costs were used in Figure 1. For Figure 2, the highest motor carrier costs were reported for the Transcontinental territory for the first five mileages and the New England region -- Group II for the remaining seven; the lowest rail cost appeared in the Southern region for all mileage blocks.

36. Terminal and line-haul costs for a representative freight car were obtained by weighting individual car costs by the proportions of the total in service in the Eastern district at the close of 1970.

37. The Eastern-Central motor carrier territory and Official rail territory encompass almost identical geographical areas.

38. The weighted average capacity of all terminal-to-terminal vehicles in the Eastern-Central territory is approximately 20 tons; it was therefore assumed that 30-ton vehicles (at average commodity density) are available for these shipments. Interstate Commerce Commission, Bureau of Accounts, Cost of Transporting Freight by Class I and Class II Motor Common Carriers of General Commodities, p. 22.

Figure 1

Minimum Motor Carrier Costs vs. Maximum Rail Costs
(Harbeson, 1970)

$/Ton \ Mileage Block Midpoint	25	75	150	250	350	450	550	700	900	1100	1350	1750
Motor Carrier Costs												
Terminal + line-haul	5.62	7.81	10.49	14.18	18.05	21.88	25.46	31.13	36.03	43.02	51.76	65.74
Δ user charge	.05	.14	.29	.48	.67	.86	1.06	1.34	1.73	2.11	2.59	3.36
TOTAL	5.67	7.95	10.78	14.66	18.72	22.74	26.52	32.47	37.76	45.13	54.35	69.10
Rail Costs												
Terminal + line-haul	4.20	5.14	6.99	9.45	11.91	14.37	16.84	20.53	25.45	30.37	36.53	46.37
Inventory -- transit time	.88	1.00	1.19	1.44	1.68	1.93	2.18	2.55	3.05	3.54	4.16	5.16
Pickup & Delivery	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72
TOTAL	7.80	8.86	10.90	13.61	16.31	19.02	21.74	25.80	31.22	36.63	43.41	54.25
Rail Cost Advantage	-2.13	-.91	-.12	1.05	2.41	3.72	4.78	6.67	6.54	8.50	10.94	14.85
High-Cost Carrier Traffic (thousands of tons)	27167	41444	69027	47825	30930	17845	13259	20041	10095	4899	3570	3357
Net Loss ($1,000)	57,866	37,714	8,283	50,216	74,541	66,383	63,378	133,673	66,021	41,642	39,056	49,851

TOTAL LOSS = $689 millions

Figure 2

Maximum Motor Carrier Costs vs. Minimum Rail Costs
(Harbeson, 1970)

$/Ton \ Mileage Block Midpoint	25	75	150	250	350	450	550	700	900	1100	1350	1750
Motor Carrier Costs												
Terminal + line-haul	11.37	13.95	15.95	19.19	22.70	27.05	32.05	39.54	49.54	59.33	72.03	92.02
Δ user charge	.05	.14	.29	.48	.67	.86	1.06	1.34	1.73	2.11	2.59	3.36
TOTAL	11.42	14.09	16.24	19.67	23.37	27.91	33.11	40.88	51.27	61.44	74.62	95.38
Rail Costs												
Terminal + line-haul	2.64	3.28	4.24	5.52	6.80	8.08	9.36	11.28	13.84	16.41	19.61	24.73
Inventory -- transit time	.88	1.00	1.19	1.44	1.68	1.93	2.18	2.55	3.05	3.54	4.16	5.16
Pickup & delivery	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72
TOTAL	6.24	7.00	8.15	9.68	11.20	12.73	14.26	16.55	19.61	22.67	26.49	32.61
Rail Cost Advantage	5.18	7.09	8.09	9.99	12.17	15.18	18.85	24.33	31.66	38.77	48.13	62.77
High-Cost Carrier Traffic (thousands of tons)	73474	67326	74193	47825	30930	17845	13259	20041	10095	4899	3570	3357
Net Loss ($1,000)	380,595	477,341	600,221	477,771	376,418	270,887	249,932	487,598	319,608	189,934	171,824	210,719

TOTAL LOSS = $4,213 millions

rail shipment is more efficient than motor carriage.[39] The estimated distances identified an efficient allocation, and the modal distribution figures were used to determine the potential traffic shifts.[40] Shipment cost components are shown in Figure 3 and the calculated distances and resulting traffic shift in Figure 4.

The results of the costing and allocation procedures for 1970 indicate that a substantial misallocation of traffic does exist and that a rationalization of the rate structure would lead to shifts in both directions and not predominantly toward rail transport, as other studies have suggested. The losses developed in the Harbeson approach are relatively smaller than those reported for 1963, mainly because the early study did not include pickup and delivery expenses in rail costs.[41] For 1970, the loss ranges from 31 percent to 5 percent of the current transportation cost of manufactured goods covered by the census figures, depending on the cost scales used in the cost comparison. The Friedlaender results suggest that an efficient allocation would require a net shift toward motor carriers. The computational errors in the original study preclude a meaningful comparison, but it is likely that the early results would indicate a greater railroad cost advantage than here because they fail to account for the different circuities associated with the two modes. One of the

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39. Circuity adjustments were made by increasing line-haul costs by 44% and 28% for rails and trucks, respectively. The distances reported are straight-line mileages.

40. Traffic shifts were based on an extrapolation of the traffic statistics that was linear with respect to both weight and distance, e.g., a distance of 260 miles required a shift from rails to trucks of 30% of the rail traffic in the 200-399 mileage block for the appropriate weight.

41. The total cost of current traffic may be calculated from the modal costs and traffic at each census mileage. The estimates of the loss relative to the original allocation were 40% and 13% for 1963 and 31% and 5% for 1970; if pickup and delivery expenses are excluded from rail costs, the 1970 figures rise to 38% and 10%.

Figure 3

Rail and Motor Carrier Costs by Size of Shipment (Friedlaender, 1970)

Terminal Costs - \$/ton
Line-haul Costs - \$/ton-mile

	Shipment Size in Tons							
	1	5	10	15	20	30	40	50
Motor Carrier Costs								
BASIC TERMINAL	29.64	14.68	7.84	5.20	4.06	3.62	4.04	3.80
Basic line-haul	.5230	.1073	.0531	.0353	.0260	.0176	.0260	.0210
Δ user charge	.0180	.0036	.0018	.0012	.0009	.0006	.0009	.0007
TOTAL LINE-HAUL	.5410	.1109	.0549	.0365	.0269	.0182	.0269	.0217
Rail Costs								
Basic terminal	98.95	19.79	9.90	6.60	4.95	3.30	2.48	1.99
Inventory-terminal handling time	.82	.82	.82	.82	.82	.82	.82	.82
Pick-up & delivery	14.08	7.66	5.14	4.04	3.08	2.72	3.08	2.86
TOTAL TERMINAL	113.85	28.27	15.86	11.46	8.85	6.84	6.38	5.67
Basic Line-haul	.2935	.0606	.0314	.0217	.0169	.0120	.0096	.0081
Inventory-transit time	.0017	.0017	.0017	.0017	.0017	.0017	.0017	.0017
TOTAL LINE-HAUL	.2952	.0623	.0331	.0234	.0186	.0137	.0113	.0098

Figure 4

Minimum Efficient Rail Distances and Traffic Reallocation (Friedlaender, 1970)

Shipment Size	Minimum Efficient Distance (miles)	Current Traffic (,000 tons) Rail	Current Traffic (,000 tons) Truck	Rail → Truck (,000 tons)	Rail → Truck (%)	Truck → Rail (,000 tons)	Truck → Rail (%)
1 ton	315	5063	41163	859	17	19378	47
5 tons	260	7673	35272	1420	18.5	16221	46
10 tons	355	8243	29994	2734	33.2	9091	30.3
15 tons	482	13293	44990	6644	50	6924	15.4
20 tons	630	27517	89979	17247	62.7	7399	8.2
30 tons	894	48907	64634	36760	75.2	2723	4.2
40 tons	129	61126	9297	9533	15.6	5846	62.9
50 tons	136	252843	25905	61969	24.5	12946	50
TOTAL		424665	341234	137166	32.3	80528	23.6

most striking results of the updated Friedlaender procedure is the increased motor carrier advantage as shipment size increases toward the vehicle limit -- the relative misallocations increase for rails and decrease for trucks as the 30-ton load is approached and then again as a second motor vehicle takes on larger loads. Finally, it is important to note that the shifts dictated by the Friedlaender methods do not contradict the rail advantages found in the Harbeson approach. It is true that the Friedlaender procedure suggests a greater net shift toward motor carrier service than the Harbeson approach. The former method produced shifts of 32.3 percent of rail traffic to motor carriers and 23.6 percent of truck traffic to railroads (Figure 4), while the latter produced corresponding shifts of 31.4 and 41.4 percent in one case (Figure 1) and 0 and 100 percent in the other (Figure 2). But, as described above, Friedlaender's costs were based on identical rail and motor carrier loads, while Harbeson's were developed for two different loads, corresponding to average shipment sizes. Employing a smaller truck load than rail load for costing purposes would, of course, increase the rail advantage. Thus, since the procedures are based on essentially the same data, the results are simply different views or representations of the same phenomena.

The significance of these results for policy decisions is restricted by several considerations, the most important of which are the limitations of the analysis.[42] Some of the difficulties inherent in the ICC cost

42. Other factors important here are the reliability of the data and the sensitivity of the results to variations in model parameters or assumptions. Costing problems aside, even the census data were not correctly specified -- the traffic distribution figures represent only shipments by firms with more than twenty employees, and only a majority of the shipments assigned to a particular commodity class need actually belong to that class. The distances calculated in the Friedlaender approach are very sensitive to the assumed maximum truck load and the magnitude of pickup and delivery costs added to basic rail costs. A maximum truck

procedures and in the evaluation of differential service costs have been outlined above. But implicit in the analysis is the requirement that the aggregate cost and output data reflect the competitive conditions prevailing in individual markets. With carriers operating at different points on the short- and long-run cost curves or on different cost curves, it is unlikely that the cost relationships estimated over a number of carriers will hold in particular markets for transportation services. Indeed, it is not difficult to construct cost conditions and efficient freight allocations for individual markets that produce evidence of an overall misallocation under the techniques described above. However, the alternative of evaluating the existing misallocations at the market level and then aggregating is not practical because the data requirements are prohibitive and because reallocations in any one market necessarily affect cost and demand conditions in related or connected markets.

It should also be emphasized that this analysis is incomplete in several ways. First, observed marginal costs are unlikely to hold over significant shifts of traffic. Reiteration of the costing and reallocation procedures to an equilibrium is required, or the cost functions (as opposed to particular observations of cost and output combinations) can be used to minimize total transportation costs. In addition, the relevance of long-run marginal cost for pricing under deregulation of rates has not been established; questions of market structure and strategy must first be resolved. Finally, the analysis is a partial equilibrium approach in the context of complete deregulation because there are several other considerations. The effect of the elasticity of demand for transport services must be weighed in reallocating traffic under a revised rate

load of 20 tons would raise rail pickup and delivery expense and motor carrier terminal and line-haul cost for a 30-ton load, thereby reducing the estimated maximum distance for efficient motor carriage of the load from 894 miles to 97 miles. And limiting the rail increment for pickup and delivery to just the cost of loading and unloading reduces the average distance for all loads to 200 miles.

structure. Other modes and commodity classes must be included. Losses other than the intermodal inefficiency must be estimated. And the dislocation or transition costs of the change must be set against the losses in a general equilibrium framework. Also, the effects of deregulation are likely to be interactive, e.g., liberalized licensing requirements for motor carriers and abandonment procedures for railroads will affect the costs that determine an optimal allocation of traffic. Obviously a more comprehensive approach is required.[43]

An alternative procedure is to model the pricing and investment decisions that a carrier will make under various technological, market, and regulatory constraints. Absent regulation, the firm can be viewed as maximizing some objective function (e.g., profits) with respect to the rates it sets and the capital (rolling stock) it assigns to various transport markets. Here the carrier is a multiproduct firm whose markets are defined by the movement of a commodity from one point to another. Production in these markets is characterized in part by the geographic connection of the markets and the joint product nature of the round trip as the firm's production unit. Regulation can be viewed as a

43. Another example of a partial equilibrium result with important policy implications is the assertation that "(motor carrier) rates would fall 20 percent generally if regulation of trucking were eliminated." Moore, op. cit., p. 6. Also see Friedlaender, op. cit., p. 74. This figure is drawn from the experience of deregulation of certain agricultural commodities in the mid-1950s. Surveys by the Department of Agriculture found that rates fell an average of 33 percent for fresh poultry, 36 percent for frozen poultry, and 19 percent for frozen fruits and vegetables. If the lower rates reflected the opportunities for previously unauthorized regulated and exempt carriers to obtain greater return loads, then it is clear that the reduction cannot be extended to deregulation in all commodities. However, the USDA studies provide no direct evidence on this point. U. S. Department of Agriculture, Interstate Trucking of Fresh and Frozen Poultry under Agricultural Exemption, Marketing Research Report No. 224 (Washington, D. C., 1958) and U.S. Department of Agriculture, Interstate Trucking of Frozen Fruits and Vegetables under Agricultural Exemption, Marketing Research Report No. 316 (Washington, D. C., 1959).

set of constraints on the pricing (rates conforming to a value-of-service pricing structure) and investment (common carrier obligations in the face of stochastic demand and entry or exit restrictions) policies of the carrier.

This modeling approach is valuable because it can indicate the overall impact of regulatory change on the decisions of a carrier, given the effect of the change on the external environment (transport demands and factor supplies). It will also be useful in describing the impact of alternative regulatory policies in markets characterized by particular competitive and demand conditions. It is less clear that the model can be used to produce a more reliable estimate of aggregate loss than those obtained above; but at least it can identify the relevant variables in the evaluation of the cost of a certain regulation. In this regard, the proposed analysis can suggest which regulatory policies are effective constraints on the decisions of the firm; this has implications for the sequence in which regulation is revised. Finally, this micro approach can provide insight into the interactions between regulatory constraints and firm decision-making, which by itself is sufficient reason for consideration.[44]

44. The formulation and evaluation of such a model is being undertaken as a portion of the dissertation research of the author.

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