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Comparative Costs of Rail and Road In Eastern India and the Coordination Of Transport Development

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I. INTRODUCTION

The most important issue in Indian transportation today is the future role of highway transport, a latecomer to the Indian scene, relative to the long-established railways which have greatly expanded their operations in recent years. In a context of expected rapid growth of traffic, are the initial overhead or "threshold"[1] costs of highway transportation warranted in terms of cost and service advantages over the existing railways? If so, should highway investments be begun now or could they more economically be postponed for an intervening period in which existing excess capacity of the railways is taken up by traffic growth, if, indeed, excess rail capacity does presently exist in a significant degree?

A reasoned answer to these questions will ultimately require a multi-faceted approach encompassing detailed traffic projections on the one hand, and an engineering economic inventory assessing the capacity, cost and service characteristics of the existing transport facilities and services on the other.[2] This paper will report on one aspect of the comprehensive evaluation of the problem; namely, the use of inter-modal cost comparisons in predicting the allocation of traffic between railway and highway transport. The study constructs estimates of the costs of transporting basic freight traffic groups by highways and railways in eastern India, and examines the significance of the findings for planning, regulatory, and pricing policies in the Indian transport sector.

The rail cost estimates are based primarily on actual broad gauge operations of the Eastern Railway, which in 1964/65 performed 37.5 billion gross ton kilometers of freight and 14.3 billion gross ton kilometers of passenger

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1 The usage of "threshold costs" given here follows that of John Meyer and colleagues, The Economics of Competition in the Transportation Industries (Harvard University Press, 1959), pp. 22-ff.

2 A simplified overall methodology for transport project planning is given in the author's Preparation and Appraisal of Transport Projects, Office of Technical Assistance, U.S. Department of Transportation, 1968. A more elaborate and formal treatment of the problem is given in John R. Meyer, ed., Techniques of Transport Planning, vol. II (The Brookings Institution, forthcoming).

service on 7,947 kilometers of running track. Detailed cost accounting techniques, in addition to statistical techniques, are employed. Since highway transport in India is small-scale, highly disorganized and severely regulated, it has been necessary in part to postulate highway transport cost functions for Indian conditions by synthesizing technical relationships observed in the United States and other countries with factor costs and capital construction costs observed in eastern India.

The potential of the existing Indian highway system, which is confined largely to single-lane paved and gravel roads without shoulders, is so low that it is apparent that major new investments will have to be undertaken before highway transportation can begin to function at the level of efficiency commonly observed in that industry in other countries. All of these additional investments are marginal costs of highway transport, so that the average incremental costs will approach long run average costs for that mode. However, the Indian railways argue that initial "threshold" railroad investments necessary to attain an efficient scale of operations are largely completed so that a large segment of rail costs may be expected to remain constant as outputs increase, and economies of scale will be present if variable costs are constant or do not rise too rapidly. In this context, the proper basis for a comparative analysis of the costs of different transport modes is the additional or incremental costs of handling the expected traffic by each mode, as measured within the time horizon of the planners.

II. FRAMEWORK FOR COMPARISON OF COSTS

We assume as a principle of transport planning that each future traffic should be allocated to (carried by) that mode which can carry it with the least total social costs (somehow defined), assuming that benefits of the different modes are the same. In fact, the service characteristics, and therefore the benefits, of rail and road transport are often quite different, so that the benefits of using the more convenient or faster mode may be more important than the cost differential. We have not attempted to quantify these service characteristics in the present paper, but they are taken into consideration in the analysis of modal choice.

Similarly, we would adopt the usual convention that in comparing alternative modes, only the optimal or least-cost technology of each mode need be considered, and that less efficient alternatives are eliminated in the intramodal choice of technology. However, in the road transport cost estimates given below, the choice of efficient intra-modal technology is merely assumed, while the railway cost estimates are those actually encountered in a given year by the existing railways, and there is no reason to believe that they reflect an optimal plant size or technology. One of the most striking omissions in this respect is that of any containerized, multi-modal movements analogous to the United States rail-highway "piggyback" services. The feasibility of establishing such services is under study by the Indian Railways, and a pilot project has been launched in western India, but no cost figures are yet available. Presumably, these and other such innovative procedures could substantially affect the competitive position of the railways in general cargo haulage in India vis-a-vis highway trucking as that industry emerges from the restricted role it plays today.

It is a basic tenet of the competitive economy that financial costs generally reflect social (or economic opportunity) costs so that an efficient allocation of resources which maximizes the economic objectives of the country results. However, it is commonly accepted that there are four major instances in which financial costs of production inputs may diverge from their social opportunity costs in a developing country such as India, and the use of financial costs in economic planning would result in a misallocation of resources.[3] These are in the prices of: (i) skilled and unskilled labor, (ii) inputs which utilize foreign exchange, (iii) capital, and (iv) inputs upon which sales and other taxes are imposed. For economic planning aimed at the efficient allocation of the country's scarce resources, these inputs should be valued at their opportunity costs, as distinct from financial costs.[4] In the present study we have made certain opportunity cost adjustments in order to correct for the most obvious distortions in financial costs between rail and highway transport.

It is generally considered that the rate of interest charged to public enterprises in India is below the opportunity cost of capital as measured by the rate of return to capital in the private sector.[5] The railways have been privileged to borrow capital from the Government of India at rates in the range of 4.5 to 4.75 percent per annum, while the opportunity cost of capital has been estimated at 12%.[6] Similarly, tariffs, excises and other taxes, which are prevalent throughout the economy, bear extremely heavily on the highway transport industry. Consequently, we have adopted a 12% rate of interest on all capital costs and have eliminated indirect taxes of primary incidence wherever possible. In the case of foreign exchange a devaluation of 58% occurred in 1966,[7] and all foreign exchange components have been valued at the new rate which probably still understates the opportunity cost, but has been taken as a reasonable approximation of 1964/65. No opportunity cost adjustment was undertaken for unskilled labor as relevant data were unavailable; this may impart upward bias to the relatively more labor intensive highway costs, but the extent of the bias is unclear.

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3 See Jan Tinbergen, **The Design of Development**, Economic Development Institute of the International Bank for Reconstruction and Development (Baltimore: Johns Hopkins University Press, 1958); A. Qayum, **The Theory and Policy of Accounting Prices**, (Amsterdam: North Holland Publishing Co., 1960); Hollis B. Chenery, "Comparative Advantage and Development Policy," **American Economic Review**, LI, no. 1 (March 1961), pp. 31-39; and Hans Alder, "Economic Evaluation of Transport Projects in Less Developed Countries: Theory and Application," in Gary Fromm (ed.). **Transport Investment and Economic Development** (Washington: The Brookings Institution, 1965).

4 But for a discussion of conceptual difficulties in the interpretation and application of partial equilibrium adjustments in economic planning, see R. G. Lipsey and Kelvin Lancaster, "The General Theory of Second Best," **Review of Economic Studies**, XXIV (1956-1957), pp. 11-32. Chenery, op.-cit., distinguishes "shadow prices" derived by application of a general equilibrium framework (linear programming) from "accounting prices" based on partial equilibrium analyses. The opportunity costs used in this study fall in the category of accounting prices.

5 Alan Carlin, "A Possible U.S. Policy Towards Indian Transportation: An Illustration of Improved Sectoral Policies," **RAND Corporation Memorandum RM-4379-AID** (June 1965); Surveys and Research Corporation (Washington, D.C.) and Coverdale and Colpitts (New York), **India Coal Transport Study**, 8 volumes, (September 23, 1963, and June 1, 1964). Henceforth cited **Coal Study**.

6 **Coal Study**, op. cit.

7 The Indian rupee was officially devalued June 6, 1966, from the former par value of Rs 4.76 = US$1 (Rs 1 = US 21c) to the current official rate of Rs 7.50 = US$1 (Rs 1 = US 13 1/3c.)

III. GENERAL COST RELATIONS AND CHARACTERISTICS OF THE TRANSPORT PRODUCTION FUNCTION

Obviously, it is not a feasible task to analyze separately the costs of each specific traffic in an area as large and complex as eastern India, let alone the whole of India. Certain generalizations must be made in order to establish some broad guidelines by which traffic may be at least tentatively allocated to different modes. The form which these guidelines take below is a series of general, discrete cost functions which depict the relationship between transport costs and the type of traffic, trip distance and size of shipment, and, in the case of highways, the size of the traffic artery. A further analysis incorporating topography was attempted, but available data were insufficient to yield meaningful results.

These figures are "typical" cost relations: in some cases they are constituted from averages over different areas and conditions; some, such as highway vehicle operating costs, reflect application of Indian prices to technical operating co-efficients based on U.S. experience; finally not a few arbitrary assumptions have been adopted where no information was available. Thus, it is clear that there may be wide divergences in conclusions to be drawn in specific situations which vary significantly from the "typical" conditions.

However, the range of conditions which can be accounted by these independent variables is relatively wide and the tables may thus approximate actual costs quite accurately in many situations. Furthermore, consideration of the general pattern revealed by the cost tables, along with the modal service characteristics, helps to identify those situations where competition between the modes is of potential importance and thus should be investigated in more detail.

A. Incremental Costs of Highway Transport

The strictly short run marginal costs of additional highway traffic in eastern India at the present time are generally rising. The basis for this assertion is that the capacity of existing highways is extremely limited in relation to present traffic demands. Possibly 70% of the highway kilometrage of the eastern region of India would have to be widened immediately or its capacity otherwise enhanced,[8] if traffic were to continue to grow over the next few years at the same rate as over the past ten years, 7.3% per annum, and transport surveys covering other areas of the country are initially reporting more or less similar circumstances. It appears that the costs of highway congestion are already significant in India and will likely become higher in the future unless highway capacity is expanded, or alternatively, highway traffic growth is diverted to other modes.[9]

Consequently, the additional investments necessary to expand the capacity of the present highway system must be included in estimates of the marginal costs of this mode over the next decade. Various alternatives for capacity expansion are available, from constructing wide new shoulders on existing

8 Based on a rough comparison of present traffic flows with existing highway capacities.

9 Which could be accomplished by various regulatory and economic mechanisms. Increasing congestion itself results in a diminution of highway service advantages; a possible highway vehicle shortage is another such mechanism aside from the usual regulatory measures.

single-lane highway and improving maintenance standards, to constructing all new two-lane highways to Indian National Highway standards.

Since a highway serves many different traffics, i.e., it is a joint or common facility whose output is a mixture of various products, the issue of allocating a portion of the highway cost to each traffic group arises. In the present study highway provision costs have been allocated on a rough, incremental cost basis for two traffic categories: (i) "light" traffic, including property owners, all passenger car traffic and light trucks, and (ii) "heavy" traffic, including all large trucks and buses. Present traffic patterns are dominated by the latter group with trucks and buses representing approximately 45% and 16% respectively, of total vehicle kilometers.

As a broad approximation it has been assumed that the existing single-lane highways would ordinarily be adequate to provide property access and could accommodate all (local and through) passenger car traffic likely to be realized within the next several years, if there were no truck and bus traffic. Consequently, 100% of the costs of expanding an existing highway to permit larger volumes and heavier axle loads have been charged to large trucks and buses. Where construction of an entirely new highway is concerned, then a proportion of the total costs sufficient to construct a single-lane, unpaved road is assessed to the light traffic category, while additional costs necessary to upgrade this road to a two-lane paved highway of appropriate design standards is assigned to the heavy traffic group. Tables 1 and 2 depict incremental highway transport costs for a one-ton shipment on an improved existing highway and for a truck load shipment moving on an all new two-lane highway to Indian national highway standards.

TABLE 1

Costs of Less than Truck Load Shipments by Trip Distance.
One-Ton Shipment with 8 Ton Trucks Moving Via Terminals (600 Trucks per day)

Existing Single-Lane Highway with New Shoulders and Improved Maintenance

Pay-Haul Distance	Total Trip Time hrs.	Fixed Annual Costs (per ton)	Vehicle Running Costs (per ton)	Terminal Costs (per ton)	Highway Provision Costs (per ton)	Total Costs per Ton	Total Costs per Ton Kilometer
1	2	3	4	5	6	7	8
25	5.14	5.17	1.00	53.8	.14	60.08	2.4032
50	5.76	5.79	2.00	53.8	.28	61.86	1.2372
100	7.01	7.05	4.00	53.8	.55	65.37	.6537
200	9.99	10.04	8.00	53.8	1.10	72.93	.3647
300	12.98	13.04	12.00	53.8	1.65	80.48	.2683
400	15.96	16.04	16.00	53.8	2.20	88.04	.2201
500	18.95	19.04	20.00	53.8	2.75	95.57	.1911
750	26.42	26.55	30.00	53.8	4.13	114.47	.1526
1000	33.89	34.06	40.00	53.8	5.51	133.36	.1334
2000	63.75	64.07	80.00	53.8	11.01	208.89	.1044

TABLE 2

Costs of Truck Load or Larger Shipments by Trip Distance

Door-to-Door Movement with 8-Ton Trucks

All New 2-Lane Highway to National Highway Standards (1500 Trucks per Day)

Pay-Haul Distance	Total Trip Time hrs.	Fixed Annual Costs (per ton)	Vehicle Running Costs (per ton)	Terminal Costs (per ton)	Highway Provision Costs (per ton)	Total Costs per Ton	Total Costs per Ton Kilometer
1	2	3	4	5	6	7	8
25	5.75	6.50	2.01	5.25	.91	14.68	.5872
50	5.99	6.77	3.25	5.25	1.47	16.75	.3350
100	6.70	7.58	5.50	5.25	2.49	20.80	.2080
200	9.12	10.31	10.00	5.25	4.52	30.07	.1504
300	11.53	13.04	14.50	5.25	6.56	39.34	.1311
400	13.94	15.77	18.99	5.25	8.60	48.60	.1215
500	16.36	18.50	23.49	5.25	10.63	57.86	.1157
750	22.39	25.31	34.74	5.25	15.72	81.02	.1080
1000	28.43	32.15	45.98	5.25	20.81	104.16	.1042
2000	52.56	59.45	90.95	5.25	41.16	196.76	.0984

In addition to highway provision costs, the costs of highway transport include the annual fixed costs of vehicle amortization, insurance, garaging, various overheads, and driver's wages, which have been made a function of time in the present study; and vehicle running costs composed of fuel, oil, lubrication, tires, vehicle maintenance and repairs, and driver's travel expenses, which are a function of vehicle travel. Unlike the lumpiness of highway provision costs, we have assumed that the number of vehicles and vehicle operating costs are continuously divisible and will expand in constant proportion as output of the highway transport industry expands.[10] This, of course, is not technically accurate, since the costs of congestion—vehicle delays and increased running costs—will rise as a given highway becomes more heavily traveled. However, these effects should not be very significant for the highway capacity-volume relations assumed here.

B. Incremental Costs of Railway Transport

Railway transportation typically involves large elements of common and fixed costs so that statistical techniques have come into general acceptance for railway costing.[11] Fortunately, Koshal[12] has recently completed a detailed statistical cross section study of Indian broad gauge railway costs and it has been possible to utilize his work in the present analysis.

Table 3 lists Koshal's regression equations for the various expense accounts.

10 Cf. the analysis of highway costs given by Meyer and colleagues, Chapter 8, especially pp. 85-93; and also Walter Y. Oi and Arthur P. Hurter, Jr., **Economics of Private Truck Transportation**, (Wm. C. Brown Co., 1965), pp. 163-176.

11 Cf. Meyer and colleagues, op. cit.

12 Rajindar K. Koshal, **Statistical Cost Analysis—Indian Railways**, unpublished Ph.D. thesis, University of Rochester, 1967. Grateful acknowledgment is made to Dr. Koshal for making a copy of his study available.

Unfortunately, many of the statistical cost estimates, drawn from Koshal, diverged widely from the actual observed values for the Eastern Railway. Consideration of the possible causes for the large errors centered, inter alia, on the size variable (which was not generally successfully included in Koshal's estimates); the composition of the locomotive fleet, as the Eastern Railway employs relatively more diesel and electric traction than the other five broad gauge railways; and the possibility that the Eastern was not operating along its long run cost function in 1964/65 due to temporary excess capacity caused by recent lumpy investments in line capacity and a sudden slowing of traffic growth. Each account was treated separately but the method most commonly used was simply allocate the observed totals among the constant, freight and passenger terms in the proportions given by Koshal's estimates while in some cases the constant term was ignored and the observed totals were simply allocated between passenger and freight traffic. The proportionate breakdown between passenger and freight costs obtained in this manner should be reasonably accurate, but the division between fixed and variable costs should best be viewed as only an educated guess at the true cost relations. Table 4 summarizes the constant terms estimated in this manner, and shows that the total constant sum constitutes only approximately 11.89% of the total working expenses of the Eastern Railway in 1964/65. The alternative of employing statistical analysis of Eastern Railway time series was generally rejected because of the very major price, technological, and output changes which have occurred in recent years and because the long run costs yielded by the cross section analysis were considered more relevant. Capital costs excluding rolling stock was the only expense account subjected to a time series analysis.

The 1955/56-1964/65 time series of total investment excluding rolling stock was deflated to constant 1964/65 prices and correlated with gross ton kilometers of passenger and freight traffic, and a close fit was obtained with $R^2 = .986$. Quite surprisingly less than one per cent of the estimated total investment less rolling stock was found to be fixed or constant; more than 99% was related to the traffic variables. This time period was one of significant technological change and very substantial growth in traffic volume, from 29.6 to 51.1 billion total gross ton kilometers. Yet the increment in capital in constant price terms (excluding rolling stock) associated with a traffic increase has remained quite stable. While there is no assurance that this will continue to be the case as new technology is employed and new plant scale attained, the estimate is taken as a reasonable approximation for predicting future investment requirements. 1964/65 replacement costs of steam, diesel, and electric locomotives and wagons were available separately and average amortization costs at 12% were employed so that costs of the different tractions could be examined separately. It is interesting to note that the passenger coefficient, Rs 2.3871 per gross ton kilometer, is more than four times the freight coefficient at Rs. 0.51927.

Tables 5 and 6 present the resulting calculations of railway cost functions related to trip distance. Table 4 represents a typical movement of less than car load traffic through terminals utilizing steam traction. Estimated local pickup and delivery costs by truck as estimated in Table 1 above have been included here also since this constitutes part—usually the major part

TABLE 3

Statistical Estimates of Indian Railway Costs*

	Constant	Passenger	Freight	Other	R^2
OPERATING COSTS					
Fuel Consumption, Steam Traction (tons of coal)	13,240	+0.0293 E_p	+0.0851 E_f		0.9752
Locomotive Running Staff	−2,133,600	+0.4023 E_p	+1.1491 E_f		0.9272
Station Staff	4,853,300	+0.002544 p	+0.000626 f		0.9678
Other Traffic Expenses	7,341,700	+0.002540	+0.000795		0.9762
Other Operating Expenses	−1,313,160	+0.002311 p	+0.001366 f		0.8905
MAINTENANCE COSTS					
Track & Structures	3,799,100	+0.003465 p	+0.002604 f	−11,708,040D	0.9966
Locomotive Repairs	−1,159,500	+0.9769 E_p	+1.1104 E_f +	− 9,486,180D	0.9364
Freight Car Repairs	2,694,200	+ .00393 f	+439.8 N_{fc}		0.8681
GENERAL ADMINISTRATION					
Maintenance of Track, Structures, Signals & Communications	− 366,919	+0.000276 p	+0.000207 f	− 931,140D	0.8494
Locomotive Supply	− 854,810	+0.1496 E_p	+0.1124 Ef	− 1,547,570D	0.8654
Maintenance of Wagons & Carriages	−1,437,420	+0.000174 p	+0.000139 f	− 1,676,300D	0.9654
Other Administration	9,376,000	+0.001682 p	+0.003233 f		0.8129

Where E_p, E_f = passenger and freight engine miles respectively.
p, f = gross ton miles of passenger and freight service, respectively.
N_{fc} = number of freight cars.
D = dummy variable.

*Source: Rajindar K. Koshal, **Statistical Cost Analysis—Indian Railways**, unpublished Ph.D. dissertation, University of Rochester, 1967

TABLE 4

Summary of Estimated Constant Costs

	Regression Constant	Statistical Error	Total Constant
OPERATING COSTS			
Line Guards, Train Passing and Inspection Staff	7173034[1]		7173034
Other Traffic Expenses	3423197[1]		3423197
General Administration	5877441	22449002	28326443
	Sub-Total Operating		38922674
MAINTENANCE COSTS			
Line Way & Structures	3554020	—7095368	3541348
Repairs to electric fixed equip.	237031		237031
Locomotive repairs (all tractions)	8326680[1]		8326680
Freight Car Repairs	32024022[2]	6977688	39001710
Miscellaneous Maintenance	2354900[1]		2354900
	Sub-Total Maintenance		46378973
INCREMENTAL			
Capital Excluding Rolling Stock (annual amortization 40 yrs. at 12%)	3500000		3500000
GRAND TOTAL UNALLOCATED OVERHEADS (Constant Costs)			88801647
TOTAL WORKING EXPENSES 1964/65			747111508
UNALLOCATED OVERHEADS AS PER CENT TOTAL (Working Expenses)			11.89%

—of the social costs of transport of small shipments. Table 6 depicts the costs of carload movements of general merchandise moving between private sidings of shipper/destinee.

IV. COMPARISON OF ROAD AND RAIL COSTS

The cost functions of Tables 1, 2, 5, and 6 have been depicted schematically in Exhibit 1. The most striking single conclusion to be drawn from the comparison of the different cost functions is that rail and truck transport costs are very close in the case of the less than car load (one ton) movement; at 100 kilometers trip distance or less the truck enjoys a very slightly lower cost while at trip distances of 200 kilometers or more rail costs are slightly less. The evidenced advantage of rail car load movements over truck load movements is as expected. However, where intermediate size shipments are involved, which may be handled economically in direct door to door truck load movements, but which would involve LCL handling, if shipped by rail, truck transport will enjoy a clear cost advantage, particularly for the shorter trip distances. This is one advantage of the greater flexibility of highway transport.

These comparisons would seem to indicate that the railways enjoy a

1 Statistical error divided proportionately among constant and variable terms.
2 Includes Rs 29.329,822 related to number of freight cars.

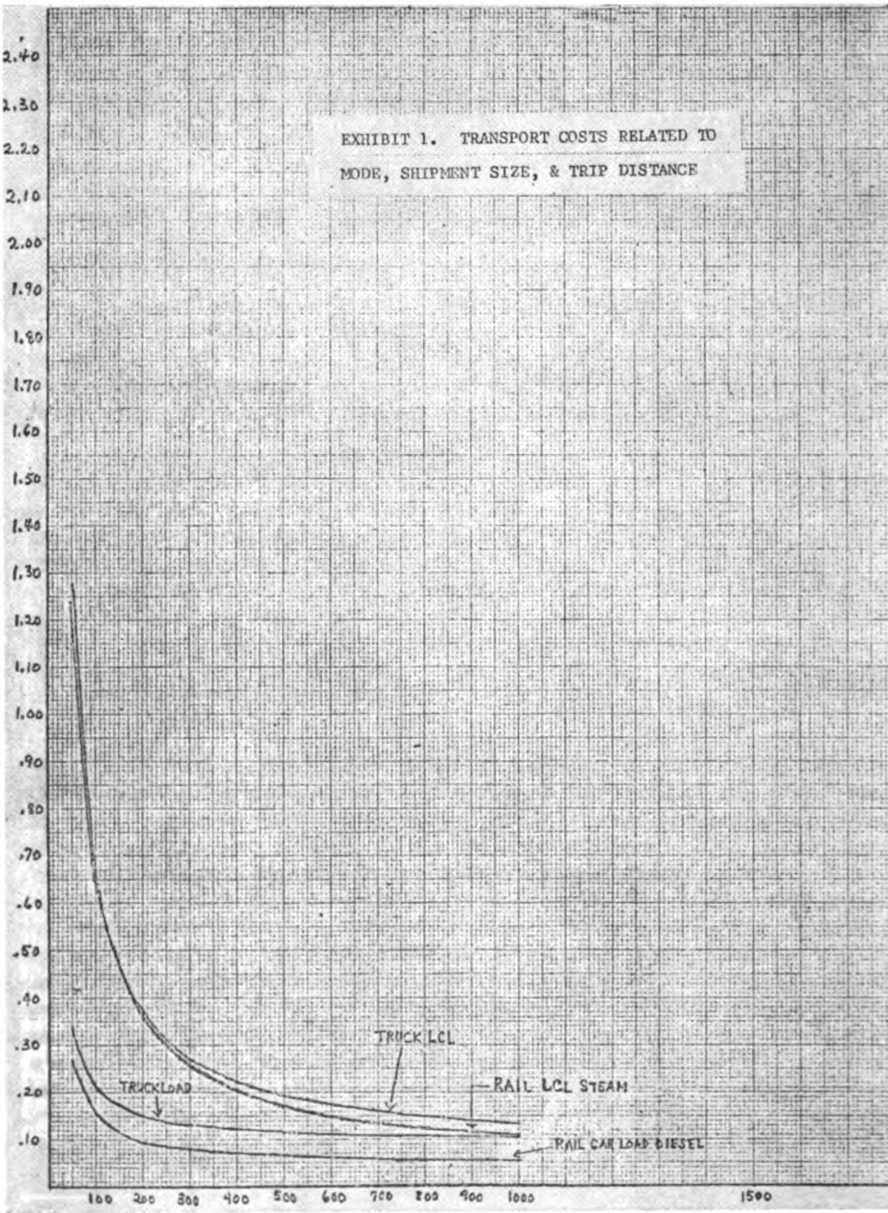
EXHIBIT 1. TRANSPORT COSTS RELATED TO
MODE, SHIPMENT SIZE, & TRIP DISTANCE
2.40
2.30
2.20
2.10
2.00
1.90
1.80
1.70
1.60
1.50
1.40
1.30
1.20
1.10
1.00
.90
.80
.70
.60
.50
.40
.30
.20
.10
TRUCK LCL
RAIL LCL STEAM
TRUCKLOAD
RAIL CAR LOAD DIESEL
100
200
300
400
500
600
700
800
900
1000
1500

EXHIBIT 1

healthy, competitive position vis-a-vis highway transport for typical freight operations where service advantages do not play a major role, and there should be ample scope to practice selective rates discrimination to make up the constant costs portion of rail costs as estimated above. On the basis of costs alone, i.e., excluding considerations of service characteristics, it could be argued, as it has indeed been argued by the Indian Railways, that the railways can fulfill the principal transport function in India with highway transport being restricted to a secondary, feeder service role. However, this ignores the very major differences in the services which the two modes serve, and unquestionably in many cases the relative advantages in speed, frequency of scheduling, and flexibility of highway transport may be expected to more than outweigh the relatively small railway cost advantages developed above.