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KEY FACTORS IN ROAD-RAIL MODE CHOICE IN INDIA: APPLYING THE LOGISTICS COST APPROACH

Peter D. Cook

GIS/Trans, Ltd.
8555 16th St., Suite 700
Silver Spring, MD 20910,
U.S.A.

Sanjay Das

Ministry of Agriculture
New Delhi, INDIA

Andreas Aeppli

A&L Associates
101 Rogers St., Suite 403
Cambridge, MA 02142,
U.S.A.

Carl Martland

Dept. of Civil Engineering
77 Massachusetts Ave.
Massachusetts Inst. of Tech.
Cambridge, MA 02139,
U.S.A.

ABSTRACT

There have been major changes in the share of road and rail traffic in India as the economy and the population has grown and become more urbanized. This paper summarizes the key factors for mode choice in freight transport that were found in India in a recent survey based on the Logistics Cost Model of shipper behavior. Both the relative importance of these factors and customer rating of satisfaction is presented.

1 INTRODUCTION

Over the last 40 years the Indian economy has changed from a base in agriculture and heavy industry to one dominated by secondary goods and services. At the same time the population has grown to over 980 million with more than 65% living in large urban centers (over 100,000).

Over the same period, the share of road freight traffic has risen from 11% to 60% in 1995, with a corresponding decrease in rail traffic. The road share of passenger traffic has increased from 28 to 80%. This pattern has accelerated in the past 20 years with total road traffic growing at about 10% per year on average compared with a 5.9 to 6.0% growth in GDP. Rail traffic grew at an average rate of 5-6% in this period, but actually decreased in 1998-99 due to the recession in heavy industry (particularly iron and steel production) which cut into rail traffic more than other modes. Although this drop in rail traffic will soon be recovered, it is a symbol of vulnerability to both economic forces and road competition.

The historic development of railways has been a major strength of the Indian economy, just as the under-development of the road infrastructure has been a restraining force. As a result of economic growth the roads which compete with the railroads in the "Golden Quadrilateral" of India, linking the major cities, are very congested. They are generally two-lane, paved roads with an increasing length of 4-lane sections. However, according to the Ministry of Surface Transport (Kumar, P. 1999), the total length of National Highways (49,585 km) makes up less than 1.65% of the total and there are "no expressways worth the name in the country". Railways boast 62,000 route kilometers covering the country, of which 60 % is broad gauge. The broad gauge lines are concentrated in the major freight corridors, where electrification and double track lines are the norm and they carried 83% of the total freight in 1995.

Although the lack of development in the road sector is being slowly tackled with the advent of taxes to support a National Highway Fund, the railways will benefit from an advantageous competitive position. This position has allowed Indian Railways to maintain a reasonable growth rate in freight traffic, without changing its approach to the freight market.

This situation, however, is likely to change with the expected improvement in road infrastructure over the next 5-10 years. The Indian Railways will face much stiffer competition which could result in even faster erosion of the rail mode share.

2 INDIAN RAILWAYS LONG RANGE DECISION SUPPORT SYSTEM (LRDSS)

In order to improve its forecasting of freight and passenger traffic, the Indian Railways initiated the development of a Long Range Decision-Support System in 1994, which has recently been completed. Six modules make up this system, and one of these six is a Market Analysis Module that is based in large part on a national shipper survey and a traffic origin-destination survey.

The shipper survey carried out for the LRDSS was designed to fit a Logistics Cost Model for road-rail mode choice. The scope of the survey is detailed in Annex A. The Logistics Cost Model is described below.

3 MODE CHOICE AND THE LOGISTICS COST APPROACH

3.1 Background to Freight Mode Choice Modeling

At the core of any marketing analysis is an attempt to understand and formalize the behavior of customers or consumers of the product or service. This understanding of, and willingness to respond to customer needs is at the core of the return to profitability of the North American Railroads in the past decade.

In general, economic theory tends to treat such customers as utility (or satisfaction) maximizers. For profit-making firms, utility is generally treated as equivalent to economic returns or profits. Since profits are simply revenues net of costs, one can quickly transform such behavior into cost minimization policies. Not-for-profit organizations (such as government agencies) can also be modeled in terms of cost minimization, since they generally will seek to use resources efficiently and well. This approach to consumer behavior is particularly relevant to an understanding of how shippers select between competing modes of transport. Shippers can be expected to seek the mode that will minimize their *total logistics costs*. This is not, however, to say that they will always seek to use the mode with the lowest *rates*. Firms recognize that there are a number of factors which can add to their costs, including the level of loss and damage, additional inventory which must be held to avoid stockouts, the value of in-transit inventory, and the reliability of a mode's services. Rational managers will come to know the costs of all these sorts of factors to their agency and will seek to reduce the total costs.

Understanding and estimating the total logistics costs of customers is at the heart of market analysis. These total logistics costs are linked to the probability that a shipper will select a particular mode for transport. As the characteristics of a shipment or shipper change, the likelihood of choosing one mode over another will also change. Systems for understanding markets, then, requires a two step process. First, the total logistics cost of the shipper must be estimated, and second, the cost must be used in a demand model.

Estimating the total logistics cost faced by a shipper requires an understanding of the factors which influence the costs, and data to calibrate the model formulation. There is an extensive literature of ways to model the total logistics cost faced by a shipper. Vieira (1992) modeled them as falling into one of eight categories:

1. <u>Order and handling costs</u> – all the administrative and handling costs associated with placing, tracking, and processing an order for a shipment of materials.
2. <u>Transportation charges</u> - freight and other special charges associated directly with the movement of the goods.
3. <u>Loss and damage costs</u> – including the actual value of the material lost or damaged for which the shipper is not compensated by the carrier, capital or carrying charges associated with tying the remaining material up during claim processing, and any processing charges.
4. <u>Capital carrying cost in transit</u> – includes the cost of capital of the goods while they are in transit.
5. <u>Inventory carrying cost at destination</u> – this is the capital cost of the goods at the final destination, and is a function of shipment size.
6. <u>Unavailability of equipment costs</u> – capital carrying costs due to the unavailability or late arrival of transportation equipment to make the movement.
7. <u>Service reliability costs</u> – This includes a number of costs, depending on whether a shipment arrives early or late relative to the planned time of arrival. In the event of early arrivals, it includes the cost of extra storage space and personnel to process the shipment. Late shipments are subject to either stockout costs or the carrying costs for inventory held for the purpose of avoiding stockouts.
8. <u>Intangible service costs</u> – these include the costs associated with aspects of service quality not captured in the trip time and reliability, such as the ability to trace shipments, EDI, capability, payment and billing processing, etc. (These are often not included because of the difficulty in attaching a specific cost.)

For each of the these elements, it is necessary to describe a formulation for the precise calculation of the costs, which are then summed to the total logistics costs.

In order to calibrate any demand model, it is necessary to have cost information regarding the competing modes (at least insofar as those costs affect the shipper's rates), the shipper's total logistics costs, and historical data regarding mode splits. One can gain these from a number of sources, including shipper surveys, historical or publicly available data sets, and estimates using standard formulations (see, for example, Chiang et al. 1981, which proposes a framework which has been applied in a number of subsequent models). In rapidly changing environments, it is preferable to rely on carefully designed and collected survey data, since the historical data will be based on institutional assumptions which no longer hold.

Once the total logistics costs are known, they can be used to estimate the probability that a customer will use rail or motor carrier for moving a shipment. Since the decision of which mode to use necessarily excludes the other, the choice can be thought of as a binary ("0-1") decision, or a discrete choice. When considered over a large number of shipments, the result is that for a given difference in total logistics costs between truck and rail, there is a probability that the shipper willchoose rail. For a number of reasons, such choices have usually been modelled using the Logit formulation. Much of the appeal of the Logit model has been its analytic convenience (see, for example, Pindyk and Rubenfled 1981). This modelling approach, its widespread usage notwithstanding, presents a number of potential difficulties in the IR case.

First, and most importantly, it requires accurate calibration *over the entire range of costs or shipper attributes being modeled.* That is, if the model is calibrated over a set of choices for which the costs are similar, the model cannot be expected to give reliable results in ranges where the relative costs are even modestly different. In a developing economy, and particularly in one undergoing considerable regulatory and commercial reform, cost functions outside the ranges historically observed are likely to be the norm rather than the exception.

A second, related problem is the relatively high level of data required to calibrate the models. While this is likely to be problematic in any formulation, it is particularly so for a Logit formulation. For example, Vieira found goodness of fit measures on the order of .2 to .4, and maintained that these are generally consistent with those of other researchers. This is primarily driven by the fact that his data, while relatively reliable for one of the modes (rail), was not particularly reliable for others. It is unlikely that in the IR case the shippers themselves will have fully come to terms with their newfound options, and so it may be beneficial to seek a more robust framework. This is discussed in the next section.

3.2 Logistics Cost Model Framework

To remedy these concerns, a new model was developed. The model uses commodity characteristics (value, density, and shelf life), customer characteristics (generally traffic patterns such as typical annual shipments), modal characteristics (rate, capacity, trip time and reliability, loss and damage figures, equipment availability, and processing costs), and calculates the total logistics cost for each mode. The total logistics costs associated with movement by a mode are calculated as the percent of the market price or value of the commodity (expressed in price per ton.) These cost percentages are then applied to a simple statistical model, using a normal distribution and the difference between the modal cost percentages to determine the probability that rail (or, in principle any particular mode) is the cheaper mode, and the assumed resulting mode share is derived.

The underlying assumption of this initial calculation is that the shipper knows the full set of costs he faces, and can "justify" the mode split on the basis of accurately measured and understood costs. In practice, this is not a realistic assumption. We know, for example, that some shippers will weigh more easily measured attributes more heavily than less conspicuous ones, and that most shippers give an advantage to faster, more reliable service. Further, this advantage to high quality service is, in some sense, "above and beyond" that associated with factors such as capacity, ordering charges, or other "quality factors". The model recalculates the mode split in light of this, using an adjustment factor. In effect, this term measures the additional value per ton (as a percentage of the total market price) that a shipper is willing to pay to receive the "superior" mode. As a practical matter, this premium will fall into a range between zero and the estimated cost percentage for the premium mode. After this adjustment is made, the mode share is recalculated, again using the difference between the relative costs.

It is important to note that this differential for superior service need not be directly related to particular measures such as trip time or distributions of travel time. Indeed, in the case of shippers who have been captive to a mode and are suddenly free to experiment with other choices, there may be a very strong predilection to "settle scores" or otherwise bias against the historical mode. To address this, the adjustment factor is also used.

3.3 Data Requirements

To calibrate the model, users need the following types of data:

3.3.1 Commodity Characteristics

These are relatively straightforward, and include:

- value per pounds (or ton),
- density measured in lb./cubic foot,
- shelf life of the product in days.

Generally these should be available either in preexisting studies (such as Roberts's 1976 analysis described in Chiang, et al., 1981), or obtained from the shippers.

3.3.2 Customer Characteristics

These characteristics are more properly the characteristics of the traffic than customer attributes *per se*. They include:

- annual volume in terms of weight shipped typically shipped to consignees per year,
- annual carrying cost (as a percentage),
- typical length of haul or distance shipped,
- number of origin-destination points served.

Some of these can be determined from traffic data in the railway's possession, while others will require either use of survey data or the results of earlier studies.

3.3.3 Modal Characteristics

For each mode, values needed include:

- order cost per shipment,
- rate per mile,
- capacity of a typical vehicle in terms of weight and volume,
- trip time and 95th percentile,
- percent loss and damage (including pilferage),
- claim processing time,
- loading costs per shipment for that mode,
- percent of shipments for which equipment is typically unavailable, and associated extra inventory.

This logistics cost model framework formed the basis for the shipper survey that was applied in India. However, it was modified in light of the local circumstances in India and the responses to the pilot survey. The names of the factor groupings were also changed to reflect the fact that they also measured the performance of the modes.

4 KEY SURVEY RESULTS

4.1 Key Factors for Customer Needs and Preferences

The most important needs of Indian customers were identified from the survey in terms of the service parameters desired from transport suppliers. The top fourteen factors are listed in the table below along with the average importance value (stated preference) accorded to each on a 10 point scale.

Importance decision parameters from the survey were classified into five categories as shown in Table 1. The following observations can be made:

1. Reliability of services and availability of the equipment at the required time and in required quantum, are the two most deciding factors in mode-choice. Of course, a mode will enter into the shippers "consideration-set" only when it is available as an option at the point of consumption/need.
2. Price and transit time are the second most important parameters for mode-choice.
3. Connectivity is taken as part of product-suitability (equipment-suitability) for mode-choice considerations by the shippers.
4. Various other parameters such as loss and damage, access to decision makers, customer friendly attitude of the staff of the transporter, ease of payment, negotiability, the time involved in processing claims and information available to customers become very important on a case to case basis through on an overall basis these fall behind the above mentioned criteria.

Table 1: Importance of Key Factors

Importance-Parameters	Level of Importance (On a scale of 10)
Category "A" Quality Parameters	
Reliability	8.68
Availability	8.50
Category "B" Product Specifiers	
Price	8.20
Transit Time	8.16
Category "C" Product Specifiers	
Connectivity	7.99
Product Suitability	7.86
Category "D" Other Factors	
Loss and Damage	7.46
Customer Information	7.37
Adaptability	7.23
Customer Friendly attitude	7.11
Negotiability	6.89
Category "E" Other Factors	
Access to decision makers	6.62
Ease of payment	6.50
Claim processing time	6.41

Source : AFF-Shipper survey (1997)

4.1.1 Customer Perceptions of the Key Factors in Mode Choice

This section presents customer perceptions about transport services, and enumerates key transport problems faced by them.

Satisfaction Index

For each of the key criteria involved in the mode choice, the respondents were asked to rate the level of satisfaction with road / rail against each of these criteria. Table 2 illustrates the average satisfaction score obtained by road and rail for each of the criteria involved for all the commodities combined:

Table 2: Satisfaction of Customers with Mode Performance

Importance-Parameters for Mode-choice	Level of Satisfaction (On a scale of 10)	
	Road	**Rail**
Category "A" Quality Parameters		
Reliability	8.34	4.60
Availability	8.41	4.61
Category "B" Product Specifiers		
Price	7.57	5.94
Transit Time	8.12	4.89
Category "C" Product Specifiers		
Connectivity	8.74	3.72
Product Suitability	7.76	5.42
Category "D" Other Factors		
Loss and Damage	8.00	4.52
Customer Information	7.02	3.55
Adaptability	7.78	3.24
Customer Friendly attitude	7.47	3.37
Negotiability	7.79	2.78
Category "E" Other Factors		
Access to decision makers	7.62	3.65
Ease of payment	8.06	3.97
Claim processing time	7.71	2.68

Source : AFF - Shipper survey (1997)

The weighted average composite satisfaction index for road & rail are shown in Table 3.

Table 3: Weighted Average Satisfaction by Mode

Mode	Weighted Average Score (on a scale of 10)
Road	7.82
Rail	3.91

Source : AFF - Shipper survey (1997)

The following can be inferred from the above tables :

1. Roadways have a far better satisfaction score than railways
2. The railways compare unfavorably against roadways on all the criteria involved. The score of railways especially on certain criteria like Ease of payment, connectivity, negotiability, claim processing time is much lower than roadways.
3. Even on the factor of price, the highest rated factor for rail, the railways do not fare as well as would be expected

Thus, the above ratings are an indicator of the fact that the railways in India have to gear up on almost all fronts to meet the challenge posed by the roadways.

4.1.2 Variations by Product Type

The survey results indicated a wide variation in importance and satisfaction of respondents according to the commodity group or industry of the respondent.

To illustrate this point we have selected four different commodities: coal, chemicals, consumer durables and foodgrains. The importance of key factors is given in Table 4.

Table 4: Relative Importance of Selected Factors for Different Commodities (on a scale of 10)

Commodity	Reli-ability	Avail-ability	Price	Transit Time
Coal	9.00	8.61	9.22	8.56
Chemicals	8.48	8.48	7.61	8.23
Consumer Dur.	9.22	9.00	8.00	8.67
Foodgrains	8.67	9.33	6.67	8.00

The interesting variations in this table show that Price is the most important factor for coal, but all four factors are very close in importance. For chemicals and consumer durables, reliability and availability are the most important, since the value of inventory stocks are more important. For foodgrains, availability is the critical factor, since they are seasonal in nature and price is less important, since it is a very competitive market, with low prices guaranteed. Reliability is important because spoilage costs are high (which also increases the value of availability).

For container traffic the survey showed that connectivity was the most important factor and all others were relatively low. This reflected the multimodal nature of the shipments, which relied on the road-rail connections to meet the shippers' goals.

The relatively low satisfaction with rail services shows up in Table 5, but it is clear that the coal shippers are much happier with their service than the others. This is because they get priority treatment by the railway as a matter of government policy and they amount to the largest volume of business for the railway, with the least problems in handling and losses.

Chemical shippers rate the railway very low in satisfaction and seem to feel that the service performance is low across the board. Consumer durable shippers, on the other hand, feel that price and transit time are well matched to their needs, but not reliability and availability. Food grain shippers are the least happy with their service, despite the priority they receive and the price break they get from the railway. The lack of service to meet their seasonal needs shows up in their rating of customer friendliness which is below 2 on the scale of 10.

Table 5: Rating of Rail Service for Selected Factors for Different Commodities (on a scale of 10)

Commodity	Reli-ability	Avail-ability	Price	Transit Time
Coal	6.00	6.06	6.24	5.71
Chemicals	3.86	3.57	4.36	3.93
Consumer Dur.	4.75	4.25	6.75	7.25
Foodgrains	4.00	3.67	2.67	3.33

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APPENDIX A: OBJECTIVES, SCOPE AND COVERAGE OF THE SHIPPER SURVEY

SURVEY OBJECTIVES

To determine those elements of the road and rail transport system which determine the choice of road or rail shipment in major transportation corridors, with specific attention to those commodities which represent potential rail traffic. Prime importance to be given to identifying and interviewing those individuals who represent a cross-section of decision-makers who control the transport decisions for major commodities.

SCOPE

The survey should:

a) be conducted in 10 major cities to be selected for their pertinence to potential rail traffic;
b) have a total sample size of 600-750, covering both private and public organizations, including shipping agents, freight forwarders and major transporters. These will include major shippers currently using rail, but with potential to ship by road in the future;
c) include information on at least the following factors:
    - nature of business and product line
    - traffic volumes between different O-D pairs by mode
    - existing formal and informal arrangements for transportation
    - shipment size(s) and packaging/ handling characteristics
    - cost of transportation
    - reliability of the alternative modes
    - type of decision-maker and informal rules followed
    - reasons for selection of different modes

The survey results will be input into a computer and processed to summarize the results. Quality control will be exercised to ensure that questions are posed in a manner that will not bias the results.

METHODS

The following considerations must be taken into account by the Contractor:

a) The survey questionnaire will be designed using best market survey practice;
b) Pilot surveys will be carried out to test the design and appropriate modifications made in the questionnaire or related procedures;
c) The survey will be designed to provide input into a mode choice model whose general design is available from the LRDSS team;
d) The Contractor is expected to work closely with the Consultant/LRDSS team to develop a thorough understanding of the requirements and ultimate use of the survey results.

COVERAGE OF THE STUDY

The survey was conducted among 375 shippers covering 43 industry segments spread over 4 regions as follow:

Industry Groups Covered: Survey has been conducted across 43 Industry groups. (See Table A1)

Regional Spread: Contacts are evenly distributed over North, South, & West. Lower number of contacts in East reflects relatively fewer but larger shippers in this region.

Shipper-Sizes: Contacts cover a range of big and small shippers, ranging from less than Rs. 50 cr. to more than Rs. 500 cr. turnover companies. (see Figure A1)

Table A1: Study Coverage: No. of contacts and O-Ds by Industry Sector

INDUSTRY CODE	PRODUCT CATEGORY	No. of Contacts	NO OF O-Ds
1	Power Plants	7	23
2	Fertilizer	18	209
3	Pesticides	2	32
4	Cement Plants	30	325
5	Mining / Quarrying	10	88
6	Refractories / Ceramics	3	46
7	Steel	20	216
8	B L : Petroleum	6	52
9	B L : Lubricants	4	34
10	B L : LPG	1	14
11	B L : Chemicals	2	30
12	B L : Industry Alcohols	1	3
13	B L : Paints	5	43
14	B L : Vanaspati / Edible oil	7	84
15	Chemicals	18	129
16	Non - Ferrous Metals	4	53
17	Metal Products	13	115
18	Petrochemicals	3	30
19	Consumer durables	10	158
20	Consumer non-durables	12	127
21	Agro : Food Processing	13	99
22	Agro : Tea	4	35
23	Agro : Coffee	4	28
24	Agro : Sugar	10	90
25	Agro : Cotton	1	9
26	Agro : Beverages	3	17
27	Agro : Tobbaco	3	27
28	Agro : Cooperatives	8	255
29	Agro : Marine Products		
30	Agro : Salt	1	21
31	Agro : Milk Products	2	21
32	Perishables (Excl. Milk)	8	72
33	Electricals / Cables	8	80
34	Engg. Goods	15	111
35	Textile / Yarn	18	335
36	Jute	3	20
37	Paper / Newsprint	13	137
38	Tyres /Tubes	14	206
39	Machinery / Equipments	11	91
40	Automobiles	12	122
41	Freight Forwarders	19	120
42	Couriers	7	59
43	Exporters	22	84
	Total	375	3,850
Source : AFF - Shipper survey (1997)			

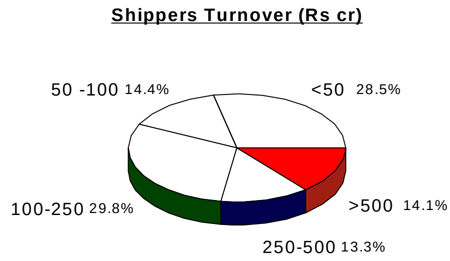

Figure A1: Distribution of Interviewees by Turnover

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BIOGRAPHIES

PETER COOK is a Vice President of GIS/Trans, responsible for the development of decision-support systems for U.S. and international businesses and agencies in the transportation field. He has been working in India for four years with the Indian Railways and is involved in many transportation projects around the world. He has worked in the World Bank and was a visiting lecturer at MIT.

SANJAY DAS is an government officer in the Ministry of Agriculture, Fertilizer Department which is responsible for distribution of fertilizer around India. He has previously worked with the Indian Railways as part of the LRDSS Team and was responsible for analysis of the shipper survey. He has an MBA degree.

ANDREAS AEPPLI is President of A&L Associates, and has carried out a number of studies of railway and shipping both in the U.S. and internationally. He was responsible for the design of the survey in India and the adaptation of the Logistics Cost Model to the study.

CARL MARTLAND is a Professor at MIT in the areas of Transportation Management and has been active in many areas of railway and multimodal research. He is the inventor of the Logistics Cost Model as presented in this paper.