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AN ASSESSMENT OF TRIP TIMES AND RELIABILITY OF BOXCAR TRAFFIC

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1. Introduction

The rail industry has appreciated the importance of service reliability for more than 20 years, dating back at least as far as the series of studies sponsored by the Federal Railroad Administration and the Freight Car Utilization Program in the 1970s [1]. While these earlier studies often focussed on issues such as equipment utilization and conceptual frameworks for changing institutional patterns of behavior, they clearly documented the need for improvements in trip times and reliability to retain shipments in the face of truck competition. Economic deregulation and changing logistics patterns by shippers caused the traffic base of many railroads to shift from single car shipments to bulk movements and intermodal traffic. Single carload traffic which continued to move on the railroads was often either very time-sensitive (such as auto parts), or not at all time-sensitive (such as waste paper). Railroad executives, recognizing that attracting and retaining profitable traffic requires highly reliable service, began to revisit these issues through the Association of American Railroads (AAR) in the late 1980s and 1990. The Research Committee of the AAR established a Reliability Subcommittee in 1990, which asked the Affiliated Laboratory at M.I.T. to look into the current levels of reliability and report on research needs. The result of that inquiry was a series of recommendations and research priorities. One of the research needs identified was to "[c]onduct an audit of railroad reliability, including general surveys of O-D, line and terminal reliability as well as more thorough investigations seeking insights into the causes of unreliability."[2] This paper reports the findings of such an audit of trip times and reliability for boxcar traffic.

Boxcar traffic was selected as the first group to be analyzed for several reasons:

- Boxcars are a significant segment of the car fleet, and traffic moved in such cars represents an important, albeit declining, share of overall railroad traffic.
- Boxcars were a central focus of industry-sponsored studies in the 1970s. As such, analysis of this traffic permits comparisons between present and past levels of service.
- Data for these cars is readily available from the AAR's Car Cycle Analysis System and Paired Event Data Set.

While boxcars represent a decreasing share of the overall railroad car fleet and car mileage, they are still important to both carriers and shippers. Between 1980 and 1988, the number of boxcars declined from 337,433 cars to 143,796 cars[3]. Similarly, the number of loaded freight car miles declined from 3.85 billion miles to 1.93 billion miles. As a percentage of total loaded car miles, the boxcar's share fell from 26.3% to 14.5%. Notwithstanding these declines in numbers, the remaining traffic is clearly important to railroads, particularly that traffic which represents "just-in-time" services to the auto and other manufacturing industries, and high revenue movements such as paper and paper products. Put simply, no industry can afford to disregard the level of service being offered to one-seventh of it's revenue base.

Earlier studies of the level of service provided to boxcar traffic include case studies of individual railroads and terminals, and a few origin-destination (O-D) analyses performed as part of probes of other factors, such as mechanical reliability[4]. The data reported in these studies provides a baseline for comparing the present levels of service.

1.1 Resources Available

The resources available to study boxcar trip times and reliability were a key factor in deciding to examine them ahead of other traffic movements. These resources include:

- *Car Cycle Analysis System (CCAS) Data* - This data includes basic car movement information for cars (such as time of placement for loading, time released loaded, time placed for unloading, and time released empty[5]. This provides the necessary information for creating and analyzing both loaded and empty car cycles. The data is collected by the AAR, and constitutes a ten percent sample of all movements reported via Train II. Because of problems in the data, some care must be taken to insure the integrity of the data. Data were provided for a twelve month period covering November 1989 to November 1990. Associated data files for Standard Point Location Codes (SPLC) and Standard Transportation Commodity Codes (STCC) were also made available.
- *Paired Events Data Set* - This data relates particular matched events in the car cycle, such as arrival at a location and departure from that location, or placement for loading and release loaded. These data can be used to examine the statistical distributions of various types of events, including train connection times at a yard, or times to load or unload cars.

The primary source used in the study reported here was the CCAS data. CCAS is mainly designed for the analysis of car cycle time. The car cycle time is defined as the time from when a car is placed empty for loading until it is again placed empty for loading. A car cycle is composed of several time components including shipper time (i.e., loading time), railroad loaded trip time, consignee time (unloading time), and railroad empty time. Among these components of the car cycle, our primary interest was on the analysis of loaded trip time and its associated reliability. The loaded trip time is directly perceived as service performance by shippers.

The CCAS data provided represents a 10% sample of all boxcar movements reported through TRAIN II during the twelve month period from December 1989 to November 1989. In the car cycle data, some records have missing information (such as no shipper times or missing empty trip times). In such cases, it is still possible to use the available data to generate some part of the car cycle, but care must be exercised in using partial records. Approximately 25 percent of the records in the CCAS data set were found to be complete.

1.2 General Methodology

The study was organized into several steps:

1. A 10% sample of the CCAS data set was selected and analyzed, representing a 1% sample of all the boxcar movements reported in the study period. This allowed a number of measures to be estimated, including descriptive statistics such as the volumes of shipments by car owners (i.e., car initial), number of carriers in the route, and the mix of commodities. It also permitted some performance measures to be estimated, including mean trip time, standard deviation, and coefficient of variation. This random sample contained 23,823 records, where each record corresponds to an individual movement.
2. The 100 O-D pairs with the highest volume of shipments (number of car movements) were selected and analyzed in greater detail. These trips were analyzed in terms of a number of potentially significant factors, including length of haul, commodity characteristics (such as value), number of carriers in the route, seasonality, and day of loading. The 100 largest O-D pairs were selected from the full data set (as opposed to the 10% sample in item 1, above), and comprise 12,119 records. Again, the mean, standard deviation, and coefficient of variation were computed.
3. A sample of 60 smaller O-D paris were also selected to permit comparisons of the level of service offered and provided to small shippers v. large shippers. These records were also selected from the full data set, and comprise 645 records. These smaller O-D pairs

constitute a 1% sample of the remaining movements after the 100 largest O-D pairs are removed. The same measures were calculated, and various statistical tests performed.

In addition to the above analyses, a comparison with the results of earlier studies was made. The results of the analyses are presented in Section 2. The results are discussed in Section 3. In section 4, future research is discussed. Before turning to the results, however, it may be useful to comment briefly on the reliability measures used.

1.3 Trip Time and Reliability Measures

As indicated, the primary focus of the analysis was the trip time and associated reliability of the loaded movement portion of the car cycle. To analyze this, the mean, standard deviation, and coefficient of variation were calculated as trip time measures, and various n-day percent measures were calculated as reliability indices.

The mean and standard deviation can be used to characterize the distribution of trip times. The mean simply reports the average trip time, while the standard deviation reflects the spread of the distribution. Compared to the normal distribution, we would expect rail freight trip time distributions to be generally skewed to the right as a result of minimum travel times and occasional long trip times due to various delays. The existence of extreme values often limits the usefulness of the mean as a measure to indicate average performance level and of the standard deviation as a measure of the compactness of trip time distributions. Eliminating extreme values before computing the trip time and reliability measures is appropriate if there is reason to suspect that such values represent data errors or highly unusual circumstances. For our analysis, we excluded extreme values (defined as values more than 4 standard deviations beyond the mean trip time), since a review of the data suggested that they were usually compound trips (e.g., cars routed CR-GTW-CR-GTW-CR-GTW). The coefficient of variation is the ratio of the standard deviation over the mean. It is useful for comparing O-D pairs which are quite different in length, or in some other measure which affects the absolute size of the mean and standard deviation.

Maximum n-day percent is the maximum percent of cars which arrive at a destination within an n-day period. For example, the 2-day percent measures the largest percent of the cars arriving in any time window which is two days wide. This measure is independent of predetermined schedules, relatively insensitive to excessive data values or data errors, and not highly related to the mean value. It is generally considered to be closely related to the shipper's perception of the compactness of trip time distributions. Because maximum n-day percent is not related to schedules, it can be argued that it is more a measure of trip time consistency than reliability per se. It is also possible to calculate the n-day percent centered about the mean or the scheduled arrival time (if schedule data is available). The n-day percent centered about the mean measures the percent of the traffic that arrives within a window which begins n/2 days before the mean, and ends n/2 days after the mean. This measure is most appropriate if the trip time distribution is normally distributed and shippers attach equal values to shipments slightly "early" or slightly "late".

In addition to the maximum and mean-centered n-day percent measures, the percent-n-days-early and percent-n-days-late were calculated for some of the movements. Percent-n-days-early measures the total percent of the traffic which arrives n-days prior to the mean, and the percent-n-days-late measures the total percent of the traffic which arrives n-days later than the mean value. These measures help in distinguishing between two movements (or classes of traffic) which have similar maximum n-day percents but different directions of skewedness. For example, it would be expected that a high-value commodity or "just-in-time" movement would have a higher percent-n-days-early than a low value commodity when all else is equal.

2. Results

In this section we look first at the analysis of the 10% sample from the CCAS data set (representing 1% of all movements in the period December, 1989 to November, 1990). Attention is then turned to the 100 largest O-D pair and the small movement samples.

	Partial Records			Perfect Records (N=4905)	
	N	Mean	Std. Dev.	Mean	Percent
Shipper Time	11,624	2.19	2.95	2.21	8.6%
Loaded Trip Time	10,503	8.16	4.95	8.28	32.2%
Consignee Time	12,577	1.54	1.77	1.55	6.0%
Empty Trip Time	8,379	13.62	11.71	13.68	53.2%
Total Cycle Time	7,533	26.51	15.92	25.71	-

Table 1
Components of the Car Cycle

2.1 Analysis of the 10 Percent Sample of the CCAS Data

Components of the car cycle for the 10% sample were examined in order to estimate the overall car cycle time. Table 1 presents the results for both partial records and complete or perfect records. It is noteworthy how little difference there is between the components as derived from partial records and perfect records (which include all the components of an entire cycle). In either case, because of the highly aggregate nature of the data, care should be used in interpreting this data.

STCC	Commodity	Movements	Percent
26	Pulp and Paper	2,915	38.9%
24	Lumber or Wood	1,204	16.1%
37	Transport Equipment	882	11.8%
20	Food or Kindred Products	384	5.1%
40	Waste or Scrap	339	4.5%
33	Primary Metal	299	4.0%
01	Farm Products	230	3.1%
32	Clay, Glass, Stone	225	3.0%
36	Electrical Machinery	177	2.4%
30	Rubber or Plastic	156	2.1%

Table 2
Major Commodity Groups in Box Car Traffic

The CCAS data includes commodity data classified as 7 digit STCC codes. The components of the car cycle were analyzed at the 2 digit level. The ten largest commodity groups are summarized in Table 2. As can be seen, the three largest commodity groups represent two thirds of all the boxcar traffic. The six largest commodity groups comprise 80% of the traffic. Table 3 presents the car cycle components for the 10 largest commodity groups. The lowest trip times were found for the commodities hazardous materials (not shown in Table 3 due to low volume) (4.8 days), transportation equipment (5.6 days), and electrical machinery (6.7 days). The hazardous materials shipments are probably an anomaly of the time the data was collected, representing ammunition shipments associated with the Desert Shield build up.

We can classify traffic as local or interline movements, in which local movements are handled by one carrier, and interline movements are handled by two or more. Interline movements require that the car be interchanged between carriers, and we would therefore expect more opportunities for delay, and hence increased travel times. Table 4 bears this out; notice that both the loaded and empty trip times increase with the number of carriers.

STCC	Commodity	Shipper Time	Loaded Time	Consignee Time	Empty Time	Total Time
26	Pulp and Paper	2.26	8.73	1.55	13.03	25.57
24	Lumber or Wood	2.57	9.16	1.83	13.10	29.21
37	Transport Equipment	1.55	5.61	0.59	12.45	20.19
20	Food or Kindred Products	2.67	9.51	2.20	15.59	29.97
40	Waste or Scrap	2.42	9.73	2.16	12.27	26.59
33	Primary Metal	2.26	8.88	2.19	16.27	29.60
01	Farm Products	1.76	10.98	1.83	17.11	31.68
32	Clay, Glass, Stone	2.64	8.74	1.99	15.03	28.41
36	Electrical Machinery	4.65	6.69	2.70	12.52	26.57
30	Rubber or Plastic	3.88	9.08	2.06	15.92	30.95

Table 3
Components of the Car Cycle by Commodity Group

No. of Carriers	Loaded Trip Time			Empty Trip Time		
	Mean	Std Dev	Cf of Var	Mean	Std Dev	Cf of Var
1	6.34	4.52	0.71	11.46	11.52	1.01
2	8.48	4.62	0.54	14.58	11.05	0.76
3	10.21	4.79	0.47	16.86	11.99	0.71
4	10.78	5.35	0.50	18.41	12.12	0.66
Total	8.16	4.95	0.61	13.62	11.71	0.86

Table 4
Trip Time and Number of Carriers in Route

2.2 Analysis of the Selected O-D Pairs

The components of the car cycle were examined for the 100 largest O-D pairs and a 1% sample of smaller movements (62 O-D pairs). The results, presented in Table 5, show that the mean and standard deviation of the larger movements are noticeably smaller than those of the smaller O-D pairs. This could reflect that railroads have shipper-oriented operating policies that result in better levels of service to larger shippers. The larger O-D pairs may also receive more frequent service consistent with higher traffic volumes.

	100 Largest O-D Pairs			1% Sample of Small O-D Pairs		
	Mean	Std Dev	Cf of Var	Mean	Std Dev	Cf of Var
Shipper Time	1.49	2.12	1.42	2.65	3.29	1.24
Loaded Trip Time	5.37	3.24	0.60	7.85	5.69	0.72
Consignee Time	0.91	1.37	1.51	1.69	2.16	1.28
Empty Trip Time	11.29	11.40	1.01	14.90	13.56	0.91
Total Cycle Time	19.80	13.02	0.66	27.48	16.14	0.59

Table 5
Components of the Car Cycle for Selected O-D Pairs

Distance	100 Largest OD Pairs		1% Sample Small Pairs	
	Movements	Percent	Movements	Percent
Short	8,439	69.6%	351	54.4%
Medium	2,212	18.3%	149	23.1%
Long	1,468	12.1%	145	22.5%
Total	12,119	100%	645	100%

Table 6
Car Movements by Distance

A number of potentially important factors governing the trip times and reliability were examined for the selected O-D pairs, including distance, local v. interline movement, commodity related characteristics, and seasonality.

Turning first to distance, each of the selected movements was characterized as being either short (500 miles or less), medium (501-1000 miles), or long (greater than 1000 miles). The results are summarized in Table 6. One of the most striking results of the study was that almost 70 percent of the largest movements were short, that is, truck competitive in terms of distance. For the small O-D pairs, more than 50% were also 500 miles or less. This result is particularly interesting in light of the traditional wisdom that railroad service is only competitive beyond certain distances (often arbitrarily set at 700 miles). The data in Table 6 seems to suggest that where service and/or price is attractive, shippers do not apply a distance based rule of thumb.

For each distance, the trip times and reliability were calculated for the 100 largest O-D pairs and the 62 small ones. The trip time performance by distance is given in Table 7. As expected, the trip times for the small O-D pairs increase with distance, but somewhat unexpectedly, the trip times for the 100 largest O-D pairs do not. This may be due to a reduced number of handlings due to blocking policies which reflect either volume or customer priorities. The reliability of the movements, as measured in 2 day percent and 2 day percent centered about the mean does not show a very great difference except for the long movements (Table 8). This might suggest that the highest level of service (in terms of consistency) is being offered to long distance high volume shippers.

Distance	100 Largest O-D Pairs			1% Sample Small Pairs		
	Mean	Std Dev	Cf of Var	Mean	Std Dev	Cf of Var
Short	5.05	2.06	0.43	5.50	2.07	0.37
Medium	6.42	2.14	0.33	8.08	2.30	0.29
Long	5.29	1.04	0.18	9.45	2.89	0.30

Table 7
Loaded Trip Times by Distance for Selected O-D Pairs

Distance	100 Largest O-D Pairs		1% Sample Small O-D Pairs	
	2-day-percent about-mean	maximum 2-day-percent	2-day-percent about-mean	maximum 2-day-percent
Short	37.08	46.97	35.32	44.02
Medium	37.65	48.17	31.98	51.73
Long	79.45	81.22	35.61	48.74

Table 8
Reliability by Distance for Selected O-D Pairs

One can look in a similar way at the selected O-D pairs in terms of local and interline movements. Table 9 presents the trip time distribution results for the selected pairs. Examination of the mean trip times shows that local movements take less time than interline movements, and that for both local and interline movements, the smaller O-D pairs take longer than the larger ones. Reliability of the selected O-D pairs was also examined in terms of 2-day percent about the mean and maximum 2-day percent. It was found that local traffic has higher reliability than interline traffic for both large and small shippers. These results lead to the suspicion that the number of carriers (serving as a proxy for the number of handlings or number of interchange operations) rather than the actual distance of the move is an important aspect of boxcar service.

The data for the small O-D pairs was too sparse to support detailed examinations by commodity group (2 digit STCC code). For the larger pairs, however, it was possible to compare the loaded trip times with some of those from the 10% sample. Table 10 presents the trip times and reliability figures for most of the 100 largest O-D pairs, and the mean trip times for the commodity groups as a whole. Notice that the trip times are shorter for each of the large O-D pairs, and markedly so for most. Notice also the high level of reliability achieved for some of the commodity groups. STCC groups 24 (Lumber and Wood) and 36 (Electrical Machinery) have 2-day percents in excess of 70 percent, and STCC 49 (Hazardous Materials, probably ammunition) is better than 90%. The O-D pairs were also examined in terms of the number of STCC groups per pair. Almost all the pairs shipped only one or two commodities, suggesting that individual shippers are associated with each pair.

It is frequently noted in the logistics literature that characteristics of the commodity (such as value, density, shelf life, etc.) are important factors in mode choice decisions. We attempted to find out if the

	100 Largest O-D Pairs				1% Sample Small Pairs			
	Percent	Mean	Std Dev	Max-2 day %	Percent	Mean	Std Dev	Max-2 day %
Local	45.6%	4.95	1.69	59.5	38.3%	5.27	1.58	54.8
Interline	54.4%	5.65	2.14	45.4	61.7%	8.18	2.81	42.1

Table 9
Trip Times for Local and Interline Movements for Selected O-D Pairs

STCC	Name	CCAS Mean	100 Pair Mean	100 Pair Std Dev	Max. 2-day %	% 1 day early	% 1 day late
24	Lumber or Wood	9.16	3.84	1.04	72.29	22.71	10.93
26	Pulp and Paper	8.73	7.20	2.58	46.92	48.83	38.42
32	Clay, Glass,etc	8.74	4.28	1.40	55.29	29.41	21.18
36	Elect. Mach'ry	6.69	4.45	1.02	76.22	17.90	12.41
37	Transp. Equip	5.61	5.03	1.99	45.29	39.52	25.80
49	Hazardous Mat'ls	4.85	4.22	0.58	90.79	4.43	6.43

Table 10
Trip Times and Reliability by Commodity for 100 Largest O-D Pairs

value of the commodity was also related to the trip time distribution and reliability. To this end, each of the commodity groups was classified as low value ($0.01-0.50 per lb.), medium value ($0.51-$1.50 per lb.) and high value (more than $1.50 per lb.). Unfortunately, the only data available for this was the 1975 Commodity Attribute Data from Samuelson and Roberts[6], and even this was not useful for more than half the movements. The distribution of trips distances were examined for the value categories. Somewhat interestingly, for both the 100 largest and the 1% sample of small pairs, the among the high value commodities, almost all the moves were less than 500 miles. The trip times and reliability were examined for the value categories as well. Only the 100 largest pairs had enough data points to be of use, and it was found that the highest value goods had the lowest average trip times. Given the limits in the data, however, these results must be considered tentative at best.

In an attempt to uncover the effects of seasonality, the car movements were also classified by geographical regions, by dividing the U.S. along state lines which more or less correspond to the Mason-Dixon line. The movements were then analyzed, first in terms of geographic region (North, South, or Inter-regional), and then by the season of the year (spring, summer, fall, and winter). The intent in this design was that the effects of the seasons on railroad reliability and trip times are more pronounced in some parts of the country than in others, and this scheme might help uncover these effects.

Turning first to regional effect, for the largest O-D pairs, 69% of the movements occurred in the North, 22% were inter-regional, and 9% were Southern moves. In retrospect, this division suggests that a better distinction might have been drawn between the Far North (including Canada), mid-latitude states, and the South. In any event, using these distinctions, it was found that movements within a region tended to be predominantly short hauls (80% in the North, and 77% in the South), while interregional movements were predominantly medium hauls (61%). Table 11 presents the trip time and reliability data for the 100 largest O-D pairs. What is striking is that while the typical trip time in the North Region is much shorter, the reliability, as measured in 2-day percent, is higher for the South. (The small pair sample showed very little effect by regions.)

Region	Mean	Std. Dev.	Maximum 2-day percent	2-day percent about mean
North	4.81	1.84	52.17	43.35
South	6.09	1.81	60.59	50.50
Inter-regional	6.57	2.27	46.90	38.02

Table 11
Trip Time and Reliability for 100 Largest O-D Pairs by Geographic Region

Season	100 Largest O-D Pairs			1% Sample of Small Pairs		
	Mean	Std. Dev.	Cf of Var	Mean	Std. Dev.	Cf of Var
Spring	5.10	1.75	0.37	8.02	3.56	0.45
Summer	5.25	1.84	0.37	6.86	1.67	0.27
Fall	5.19	1.81	0.35	4.32	1.18	0.27
Winter	5.59	1.99	0.37	5.97	2.46	0.41

Table 12
Trip Time Performance by Season for Selected O-D Pairs

Season	Mean Trip Time			Maximum 2-day Percent		
	North	South	Inter-reg.	North	South	Inter-reg.
Spring	4.70	5.98	6.03	57.51	69.44	54.52
Summer	4.82	5.62	6.39	58.58	64.94	52.53
Fall	4.67	5.48	6.57	58.01	64.41	53.89
Winter	5.06	6.92	6.73	55.16	61.36	46.01

Table 13
Seasonal Effects on Trip Time by Region for 100 Largest O-D Pairs

Next seasonal effects were examined for the selected O-D pairs without regard to region. As can be seen in Table 12, trip time is not greatly different for the 100 largest O-D pairs according to the season of the year, although trip time is longest in the winter, when conditions for railroad operations are probably most difficult. For the small shippers, there is no clear pattern, and it is unclear whether this is a sampling problem or whether small shippers really experience a decrease in the level of service in the spring and summer.

When both the effects of the seasons and the geographic region are incorporated into the analysis, we find that there are some significant results. Table 13 presents the results of examining both factors. What is noteworthy is that mean trip times lengthen and the maximum 2-day percent diminishes in every region in the winter. This is consistent with the various difficulties typical of railroad operations in colder weather (including snow delays, difficulty in maintaining air pressure in trains, etc.)

2.3 Comparison with Previous Studies

One of the reasons for selecting the boxcar as the first group of cars to be studied was the ability to revisit the results from the 1970's and make comparisons. While much has changed in the industry in terms of technology, operating practices, and industrial organization, it is still necessary to move a significant number of single car shipments through classification yards and onto connecting trains. To see to what extent the trip times and reliability have changed from the past, we compared the car cycle data with results in a 1972 study [7] and a 1980 analysis which looked specifically at 50 foot boxcar cycle in the mid-1970's [8]. Table 14 compares the results of the three studies. The 1990 data is that from the 10% sample of the CCAS data set, using only complete (or so-called "perfect") records. Several caveats are in order, however, in making the comparisons. First, the underlying methodologies of the studies are not strictly comparable. The 1972 study, for example had far less data available, and is not limited to boxcar traffic. A second point to note is that the supply and demand conditions for boxcars have changed dramatically during the periods in question. There was a considerable boxcar shortage, for example in the 1970s, while today there is a relative surplus. This serves to explain the increase in empty car time - the cars are not being ordered in by customers.

	Current Study (1990)		Reebie (1972)		AAR CCAS (1980)	
	Mean	Percent	Mean	Percent	Mean	Percent
Shipper Time	2.21	8.6%	3.0	11.8%	2.0	8.2%
Loaded Trip Time	8.28	32.2%	8.5	33.3%	11.3	46.5%
Consignee Time	1.55	6.0%	3.0	11.8%	1.7	7.0%
Empty Trip Time	13.68	53.2%	11.0	43.1%	9.3	38.3%
Total Cycle Time	25.71	100%	25.5	100%	24.3	100%

Table 14
Comparison of the Car Cycle in 1990 and Previous Studies

Notwithstanding these warnings about making too much from the data, it is striking to see how similar the total cycle time is in the three periods studied. There is a steady reduction in the mean loaded trip time, but the progress must be considered slow. Of at least as much significance has been the reduction in shipper and consignee time since the early 1970s.

3. Discussion of Results

The results are summarized and discussed in this section, and some conclusions are drawn. The results can be thought of as falling into two general categories: the nature of boxcar traffic in the period studied, and the level of service being provided to that traffic.

3.1. Descriptive Results: The Nature of Boxcar Traffic

The study revealed some potentially important information concerning the general nature of boxcar movements:

- **Boxcar movements appear to be concentrated in a small number of commodity groups.** In particular, pulp and paper (STCC 26), lumber or wood (STCC 24), and transportation equipment (STCC 37) make up approximately two-thirds of all boxcar movements. This commodity mix appears to be more or less constant over the complete sample and the 100 largest O-D pairs.
- **Loaded movements typically involve more carriers than empty movements.** While only 38% of all loaded movements were single carrier moves, more than 48% of empty movements were single carrier moves. In other words, it appears that cars are being used for loaded interline movements and are then being reloaded on the same carrier or sent home by efficient routings.
- **There are a high number of short, truck-competitive movements among the largest origin-destination pairs.** Of the 100 largest O-D pairs, 65 were for distances of 500 miles or less, which constituted almost 70% of the traffic moves in the 100 largest pairs. These moves cover the same general distance as a single-day truck haul. This suggests that railroads are offering at least some important customers services or prices which allow them to compete with truckload carriers.
- **Each O-D pair among the 100 largest pairs typically handles only 1 or 2 commodity groups.** On average each of the 100 largest pairs involved shipments of 1.44 different two-digit STCC groups. This serves to suggest that the largest O-D pairs generally represent shipments from a single industrial site or customer to another customer, as opposed to simply two economically busy regions.

3.2. Results: Level of Service

The level of service provided to boxcar shippers, as measured in trip times and reliability was the central focus of the study. Level of service was examined for large and small shippers, as well as for the overall data set. In addition to traditional measures, such as mean and standard deviation, the coefficient of variation, n-day percent and percent-n-days early were calculated. Some of the most important results are characterized below.

- **There exists a substantial level of variability within individual O-D pairs, such that more than two-thirds of all shipments by commodity groups have a maximum two day percent of less than 80%.** It suggests that there is considerable room for "tightening" trip time distributions if that is desirable for attracting or retaining traffic.
- **The level of service appears to vary with the detailed characteristics of the O-D pairs, rather than with a single attribute.** There were O-D pairs with very high levels of service and others with poor levels of service which appeared to share many of the same attributes such as distance or STCC group.

- **There is a substantial difference between the level of service (measured in trip times and reliability) provided to large shippers and small shippers.** This can be seen most clearly by comparing the car cycle for the 100 largest O-D pairs and the 1% randomly selected small O-D pairs. Each element of the car cycle takes longer for the small shippers.
- **Local (i.e., single carrier) trips have better trip times and reliability than interline movements.** This was found to be true for both loaded and empty trips, and for the 10% sample, the largest O-D pairs and the small pairs.
- **Length of haul is not a determinant of level of service for large shippers; it is for small shippers.** For the 100 largest O-D pairs, increasing distance was not marked by increasing mean trip time; indeed, the mean trip time for trips greater than 1000 miles was only slightly longer than that for trips less than 500 miles. For the small shippers, on the other hand, the mean trip time increased steadily with distance. This suggests that the some other factor than line-haul distance, such as number of yard handlings, determines the trip time.
- **The level of service appears to be affected by seasonality, but only modestly so.** Analysis of trip times organized by geographical regions and by season of the year generally shows that trip times increases and reliability decreases in the winter. Trip times tended to increase by 8-25% over the best season, and reliability (measured in maximum two day percent) decreased by 5-12%. The effects appear to be more pronounced in the South than in the North. These results are generally consistent with expected difficulties in operating engineered systems (such as track and equipment) in the winter.
- **The overall car cycle does not appear to have changed greatly from that found in earlier studies.** Although the data sets are not strictly comparable, the average overall car cycle found in this study is quite similar to that in the Reebie Associates' 1972 analysis. The primary change appears to be in reduced shipper and consignee times, and longer empty car times. The former is consistent with shipper concerns with logistics, and the latter with the relative surplus of boxcars today. Another study, that of the Car Cycle Analysis Subcommittee in 1980, also found similar results. The loaded trip times in 1990 are lower than those of 1976-77, which are the basis of the study, and empty times are much higher in 1990. Overall, however, the 1972 study, the 1980, and this study find overall cycle times of 25.5 days, 24.3 days, and 25.7 days respectively.

The car cycle data was examined in terms of overall service, large shippers (the 100 largest O-D pairs), and small shippers (the 62 randomly selected small pairs). This provides a unique insight into the level of service, and can serve as a starting point for further research.

4. Conclusions

Research in railroad reliability has a number of important implications for managers, including where to focus management attention and resources, how to structure capital, operating and service plans, and even which markets to enter or exit.

While this study provides a baseline regarding service levels and reliability for a particular time period for boxcar traffic, it is by no means exhaustive with respect to railroad levels of service, nor even for boxcar traffic itself. Reliability research is continuing at the Affiliated Laboratory, and other work in this area is clearly warranted. Among the areas that call for further work are:

- detailed causality studies to determine why some movements are unreliable or inconsistent;
- assessment of the level of service reliability for other types of equipment or types of traffic;
- examination of the effects of mechanical reliability on service reliability;
- analysis of the relationship between service reliability and shipper demand.

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ENDNOTES

[1] See Freight Car Utilization Program, **Catalog of Projects and Publications, 2nd Edition**, Association of American Railroads Report No. R-453, December 1980. Many of the most important research reports are part of Martland, C.D. (ed.), **Studies in Railroad Operations and Economics**, Vol. 1-39, M.I.T., Cambridge.

[2] Martland, Carl D., Patrick Little, Oh Kyoung Kwon, and Rajesh Dontula, **Railroad Reliability in the 1980s**, M.I.T./A.A.R. Affiliated Laboratory Working Paper 91-1, April, 1991, p.5.

[3] All numbers in this paragraph are drawn from Association of American Railroads, **Analysis of Class I Railroads**, 1980 and 1988 Editions.

[4] These studies are reviewed and summarized in Chapter 3 of Martland, et. al. (1991), **op.cit.**. Of particular note are the results described on pp. 39-46.

[5] A full description of the car cycle data is given in AAR Freight Car Utilization, Car Cycle Analysis Subcommittee, **Car Cycle Analysis System**, AAR Report No. R-442, September 1980.

[6] Samuelson, R.D., and P.O. Roberts, **A Commodity Attribute File for Use in Freight Transportation Studies**, Massachusetts Institute of Technology, Center for Transportation Studies Report 75-20, 1975.

[7] Reebie Associates, **Toward an Effective Demurrage System**, Report FRA-OE-73-1, (Federal Railroad Administration: Washington, D.C.), 1972., quoted in Manheim, Marvin L., **Fundamentals of Transportation Systems Analysis, Volume 1: Basic Concepts**, (M.I.T. Press: Cambridge, MA), 1979.

[8] AAR Freight Car Utilization Program, AAR Report R-442, 1980.