Application of Motor Carrier Continuous Traffic Study Techniques to the Assembly of Intercity Freight Traffic Data

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•IN the President's proposal for a Department of Transportation, the need for the collection of adequate and reliable information necessary for the promotion and regulation of transportation was given considerable emphasis. A review of the testimony presented in support of the establishment of a Department of Transportation shows that a coordinated effort between private industry and Federal Agencies is essential to the pursuit of sound transportation policy for the economy. This cooperation is particularly critical in the development of traffic flow data.

The increasing demand from the areas of transportation planning, research, and regulation for greater reliability in information relating to intercity freight traffic requires that the commercial motor carrier industry be assisted in its endeavor to produce a valid description of the traffic it moves.

The continuing growth and consolidation of the motor carrier industry, along with the increasing role of motor freight associations in proceedings before the Interstate Commerce Commission (ICC) has brought about a demand for statistical data that will provide reliable estimates of specific operating characteristics of large groups of motor carriers operating within and between given geographic regions. To meet this demand, the ICC, relying heavily on the experience of the motor carrier industry, has designed and issued descriptive sampling plans for the development of continuous traffic studies. Although these studies seem to be directed toward regulatory objectives, they furnish equally important information concerning commodity flow patterns for goods moved by the common motor carriers of general commodities.

Experience gained from the development and institution of a continuous traffic study in the Southwestern Region suggests several possible uses for continuous traffic study (CTS) data in the establishment of reliable commodity flow statistics within and between this and other geographic regions of the United States. The primary purpose of this paper is to describe the basic design of the Southwestern Region Continuous Traffic Study. In addition, modification of the study is also suggested to make available specific data for use in the computation of commodity flow statistics for various geographic regions of the United States.

HISTORICAL DEVELOPMENT OF FREIGHT TRAFFIC STUDIES

The collection of traffic flow data originated with the beginning of commercial transport. Although earlier reports of specific movements of commodities between given points of origin and destination may be documented, Chinese historians recorded canal traffic data as early as the eighth century. Their reports indicate that over 2 million tons of commodities (mostly grain) moved along the Grand Canal from the lower Yangtze and Haui to Kaifeng and Loyang, annually.[1]

[1]Charles Singer, et al, A History of Technology, Oxford Univ. Press, Vol. III, 1957, p. 439.

Paper sponsored by Committee on Intercity Highway Freight Transportation and presented at the 46th Annual Meeting.

Traffic studies, as they are known today, are the product of many years of trial and error on the part of both the transportation industry and regulatory bodies in the development of statistically sound data reporting techniques. The waybill studies conducted by the railroad companies as far back as 1892 were pioneering efforts and served as the basis of the motor carrier continuous traffic study described in this paper.[2]

The passage of the Hepburn Act in 1906 strengthened and broadened the ICC's powers considerably. Traffic tests increased in the proceedings that followed. Through the application of these tests, traffic flow information supplied to the ICC began to improve in quantity, as well as in quality.[3] In the early 1930's the Federal Coordinator of Transportation conducted a rather ambitious study which included data relating to all rail carload traffic terminated on December 13, 1933. The sample was comprised of waybills from more than 65 thousand carloads of rail traffic. Although no attempt was made to expand these data to an annual basis, the study is significant to the development of continuous traffic studies because it attempts to produce "nationwide estimates of cost and other factors on a factual basis."[4]

Another effort on the part of a Federal agency to initiate traffic studies was begun in November 1941 by the War Department. The unique feature of this study, as compared to previous efforts, was that it utilized a "continuous sampling" plan, as opposed to the provious studies employing "spot" sampling.[5] The sample was drawn from commerical shipment waybills covering approximately 25 million shipments. Inasmuch as the bill numbers for each of the shipments were progressive, a plan was conceived to draw the sample according to randomly selected numbers corresponding to terminating digits within the bill number. This procedure produced unbiased results, and through this successful experience, the continuous sample became an important tool in the later development of the ICC's waybill study.[6]

Late in 1945, Congress authorized the ICC to establish a waybill section in its Bureau of Transportation Economics and Statistics. In this first attempt to develop a continuous traffic study for the transportation industry, the primary objective was the design and processing of data related only to railroad traffic. This program is still in effect, and although it has met with much opposition in the application of particular information derived from the waybill sample, the validity of much of the data has been certified by private, public, and institutional research groups.

The motor carriers' initial traffic studies were developed from "fixed period" sampling plans. One of the earliest traffic studies involving motor carriers was conducted during the early 1940's as part of an investigation of interstate class rates.[7] In 1945 a Federal agency again played an important role in the development of the continuous traffic study when the Office of Defense Transportation, in cooperation with some 90 western trunk-line motor carriers, conducted a one day traffic study.[8] Late in the 1940's the National Tank Carriers, Inc., conducted a 5 percent random sample freight bill analysis of all truck load traffic moved by association members during a 3-yr period.[9] Due to the successful results obtained from this and other fixed-period studies, the ICC instituted studies, similar to those conducted by the National Tank Carriers, for motor carriers of general commodities in the collection of regional cost data.

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[2] For an excellent history of the waybill studies, see Interstate Commerce Commission, Waybill Statistics Their History and Uses, Washington, D.C., Statement No. 543, 1954, pp. 1-10.

[3] Railroad Commission of Nevada v. S. P. Co., 19 ICC 248 (1910).

[4] Waybill Statistics, op. cit., p. 11.

[5] Ibid, p. 14.

[6] Waybill Statistics, op. cit., p. 14.

[7] Class Rate Investigation, 1939, 262 ICC 496 (1945).

[8] Waybill Statistics, op. cit., p. 45.

[9] Ibid, pp. 46-7.

The motor carrier continuous traffic study is a product of the early 1960's. Examples of the type of CTS currently conducted by the motor carrier industry may be found in several published proceedings of hearings held before the ICC and state regulatory bodies.[10] The increasing use of traffic study data in regulatory proceedings brought to the attention of the ICC the need for standardizing the method by which continuous traffic studies should be conducted. As a result of considerable study, the Commission, in mid-1965, released to the motor carrier industry an outline for intercity freight bill sampling plans.[11] These plans were designed for use in preparing certain required forms that are submitted by the carrier to the ICC on an annual basis.

Although regulatory requirements have necessitated the use of continuous traffic studies to meet specific statistical information demands, other factors have played a significant role in their development. Differing somewhat from earlier attempts, the continuous traffic studies as designed and implemented by the motor carrier industry of today are in part the results of recent changes in managerial techniques, in part the application of statistical concepts (specifically, sampling theory), and the application of automatic data processing technology to regulatory policy. It would be difficult, if not impossible, to arrange each of these contributing factors in order of importance.

The main contribution to this program, however, is credited to W. Edwards Deming and A. C. Rosander, through whose efforts computer technology and sampling theory have been brought together in such a manner as to make statistically sound traffic studies a reality. The practical knowledge of the staffs of several motor carriers and their respective motor freight bureaus have contributed immeasurably to the evolution of statistically sound traffic studies, and, more importantly, to practical and efficient methods for collecting the required information. In addition, the ICC has encouraged both the use of CTS data in proceedings before the Commission and the acceptability of these data in the filing of various required reports. It also appears that several state regulatory agencies have recently become aware of the value of this type information in the performance of their regulatory responsibilities.

THE SWMFB CONTINUING TRAFFIC STUDY

Late in December 1964, representatives of the Southwestern Motor Freight Bureau and Texas A & M University's Transportation Institute met to discuss the feasibility of a continuous traffic study applicable to motor carriers operating within the Southwestern Region. The study was to include 19 motor carriers having operating authorities within the geographic region shown in Figure 1. It was estimated that these carriers alone accounted for approximately 80 percent of the total annual revenue of all common carriers of general commodities operating within this region. In addition, it was estimated that these 19 carriers issued some 21 million freight bills annually.

After preliminary meetings with H. O. Hartley, Head of the University's Statistical Institute, and staff members of the Texas Transportation Institute, the SWMFB executed a contractual agreement through the University's Research Foundation for the development and implementation of the CTS project. Following these meetings, specific objectives for the development of the CTS were constituted. In general, these objectives were accomplished in the following order:

1. A complete description of the population to be sampled;
2. The basis on which individual freight bills would be selected;
3. The sampling rate for the strata of population;
4. The procedures by which the sample freight bills would be drawn and recorded;
5. Controls for the identification of each sampled freight bill; and
6. Methodology for the expansion of the sampled data to yield useful information.

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[10]Recent general rate increase cases where CTS data have been entered include: I&S Docket No. M-18827, General Increases, Between East and Territories West, Nov. 1965; I&S Docket No. M-18827 M-14704, General Increases—Eastern Central Territory, 316 ICC 467 (1962); General Increases—Middle Atlantic and New England Territory, 319 ICC 168, 176 (1963).

[11]ICC Docket No. 34540, April 1965.

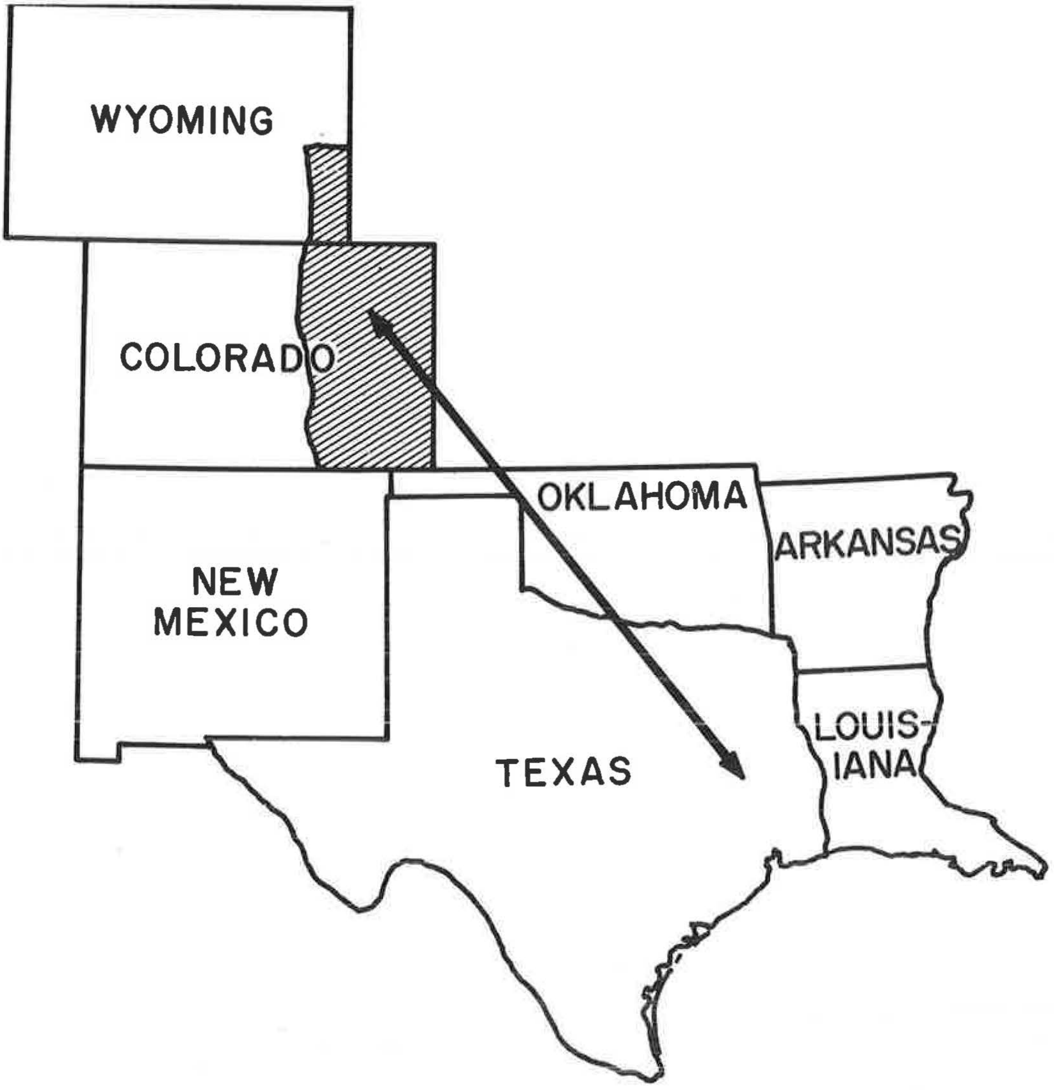

Figure 1. States included in Southwestern Region.

Although these procedures are common to the design of most CTS projects, and in fact most sampling problems, it does not mean that all traffic studies are designed with the same purpose in mind. For example, the ICC motor carrier probability sample was designed primarily to provide data for regional cost studies. As a result, the population, stratification of the population, and sampling rates described in ICC Docket 34540 were geared to this particular objective. However, the SWMFB study was initially designed to provide data for the analysis of several weight categories of individual motor carrier traffic moving within the Southwestern Region.

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ETMF

BIRMINGHAM, ALABAMA

83- 033948

CONSIGNEE

DESTINATION

DATE

ADDRESS ....CONTINUED FROM PRECEEDING PRO NUMBER....

SPOT NO. TRLR JCTS. & ROUTE BYD. ETMF

SHIPPERS NO. O. CODE D. CODE

SHIPPER

ADDRESS & ORIGIN

PREVIOUS ROUTING: CARRIER, FREIGHT BILL NUMBER, DATE, TRANSFER POINTS OF ALL PREVIOUS CARRIERS (I.C.C. RULES).

NO. OF PCS.	DESCRIPTION OF ARTICLES AND SPECIAL MARKS	WEIGHT	RATE	CHARGES
1	BOX			
1	CTN 62920 BOLTAGE REGULATIONS	135	289	390
1	BX 175320 TUBE OR TUBING STL	17	187	32
4	BX 18580 AUTO ENGINE PTS NOI	752		
1	CTN			
3	BOX 19160 AUTO PARTS NOI I/S	532	317	4070
1	CTN			
11	BOX 91750 GUN STOCKS FINISHED	1429		
1	CTN			
6	BOX 69300 FIREARMS PARTS NOI	1045	373	9228
...CONTINUED ON FOLLOWING PRO NUMBER......				

ORIGIN DIVISION OF REVENUE E. T. M. F. BEYOND TOTAL THRU CHARGES →

CERTIFICATE MC-41432
ORIGINAL PAID FREIGHT BILLS MUST ACCOMPANY ALL CLAIMS.

EAST TEXAS MOTOR FREIGHT LINES, INC.
GENERAL OFFICES-623 NO. WASHINGTON, DALLAS, TEXAS

ETMF

Figure 2. Freight bill issued by study carriers.

1-CARRIER NO [|] STATION [| |] FREIGHT BILL NO [| | | | | | | | | | | |]

2-CHANGE IN SAMPLE BILL NUMBER DUE TO: [1] Assigned No. Voided [2] Assigned No. Not in Series

3-ORIGIN [| |] FINAL DESTINATION [| |] DATE OF BILL [| | | |] (MONTH-DAY-YEAR)

4-TERRITORY: (Mark X one one No.)

INTERSTATE:

[1] Within SWMFB Territory

[2] SW Origin-Destined Outside

[3] Outside Origin-Destined to SW

[4] Origin & Dest. Outside SW-Transp. Thru SWMFB Territory

INTRASTATE:

[5] Arkansas

[6] Louisiana

[7] New Mexico

[8] Oklahoma

[9] Texas

ALL OTHER:

[0] No transp., Inter-or Intrastate in SW Territory

5-HANDLING: (Mark X over one No.)

[1] Single Line

[2] Joint - Originated by Reporting Carrier

[3] Joint - Delivered by Reporting Carrier

[4] Bridge - Received from Connecting Carrier & Delivered By Reporting Carrier to Connecting Carrier.

6-NO. OF PIECES [| | | | |] (If not shown on bill, use Bureau Scale.)

7-WEIGHT CODE: (Mark X over one No. based on ACTUAL WEIGHT.)

MINIMUM CHARGE:		OTHER THAN MINIMUM CHARGE:			
01	0- 49 LBS.	07	0- 49 LBS.	13	1,000- 1,999 LBS.
02	50- 99 LBS.	08	50- 99 LBS.	14	2,000- 4,999 LBS.
03	100-149 LBS.	09	100-149 LBS.	15	5,000- 9,999 LBS.
04	150-299 LBS.	10	150-299 LBS.	16	10,000-19,999 LBS.
05	300-499 LBS.	11	300-499 LBS.	17	*20,000-29,999 LBS.
06	500 LBS & OVER	12	500-999 LBS.	18	*30,000 LBS & OVER

* When weight exceeds vehicle capacity, treat weight in each vehicle as separate shipment, and complete separate abstract for each shipment. Clip multiple abstracts together.

8-ACTUAL WEIGHT [| | | |] THRU DISTANCE [| | | |] TOTAL REVENUE [| | | | | |]

BILLED WEIGHT [| | | |] YOUR PORTION [| | | |] YOUR PORTION [| | | | | |]

9-ABSTRACT CODE: Regular Sample [1] TL WT Check Sample [2]

10-INITIALS: ________ Carrier ________ SWMFB ________ TTI

Figure 3. The 1965 freight bill abstract form.

Implementation

On completion of the sample design, detailed sampling instructions were prepared for each participating carrier.[12] Rather than remove the sampled freight bill from the files of the motor carriers, abstract forms were provided for the transfer to specific data from carrier records and were forwarded to the traffic department of the SWMFB. Here rate analysts audited the abstracted data and entered additional information on the freight bill form. The completed abstract was then sent to the data processing section for machine keypunching and verification. The data cards were periodically grouped together and fed through the IBM 7094 computer for further auditing. Figure 2 shows a sample freight bill issued by one of the study carriers, and Figure 3 shows the abstract form that is completed for each sample bill.

DATA OUTPUT

As part of the editing process of approximately 90, 000 sample freight bills drawn from the CTS carriers during 1965, certain control data were periodically generated. These analyses showed that, with modifications in sampling procedures and the type of data abstracted from the sample bill, specific traffic flow patterns could be generated from CTS data. For example, inasmuch as each sample bill was coded by a city origin and destination, statistics relating to the flow of traffic from, between, and to any of the coded points could be assembled. In addition, each sample bill has an assigned expansion factor; therefore, estimates of total movements between coded points could be compiled.

By grouping all shipments originating within any one standard metropolitan area, it is possible to analyze the type and characteristics of traffic moving by common carrier motor freight from that point. These analyses may include, but not necessarily be limited to, such factors as weight of the shipment, number of pieces in each shipment, weight of each piece within a shipment, distance the shipment moved, revenue received by the motor carrier for the shipment, and rate per hundred-weight of shipment. In the same manner, all shipments terminating within any one standard metropolitan area may be grouped for similar analysis. These points of origin and destination (metropolitan areas) may then be grouped to provide intercity traffic flow information for standard metropolitan areas, geographic regions, individual states or several states, depending on the type of data requirements necessary to meet particular study objectives.

Traffic Flow Analysis

Assuming that CTS sampling procedures have been modified to produce sufficient observations that are representative of all shipments originating and terminating within a geographic region, the characteristics of traffic moving between specific points within that region may be defined with some degree of reliability.

Four example report forms were prepared from Southwestern Region CTS data collected during 1965. These forms illustrate the manner by which intercity traffic flow data may be assembled for analysis. Data were obtained from some 35, 000 sample freight bills representative of approximately eight million shipments originated and/or terminated by Southwestern Region CTS carriers.

CTS Example Report Form I

Table 1 gives the data available from an analysis of traffic originating in a selected standard metropolitan area (SMA) and destined to a specified point. In this example, Dallas was chosen as the traffic originating point, with Houston as the point of destination for the shipments. Published tariff distance between these two points is 242 miles. An overall average of 242. 7 miles for shipments indicates the accuracy of the data abstracted from the sample bills. Although the average weight of these shipments

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[12]For a detailed description of sample instructions issued to each study carrier, see James D. Jones, Jr., A Continuous Traffic Study As a Source of Input Data for the Computation of Operating Ratios for Selected Weight Brackets.

TABLE 1

CTS EXAMPLE REPORT FORM I—TRAFFIC[a] ORIGINATING IN DALLAS AND DESTINED TO HOUSTON

Type of Shipment (lb)	Avg. Wt per Shipment (lb)	Avg. Distance per Shipment (mi)	Avg. Pieces per Shipment (actual no.)	Avg. Wt per Piece (lb)	Avg. Revenue per Shipment ($)	Avg. Rate per 100 Lb ($)
0-49	26.5	242.7	1.7	15.6	3.15	11.91
50-99	70.0	242.6	3.3	21.3	3.06	4.38
100-149	118.8	242.7	7.2	16.4	3.47	2.92
150-299	206.1	242.7	11.2	18.4	4.41	2.14
300-499	381.2	242.7	17.5	21.8	7.29	1.91
500-999	693.2	242.6	20.5	33.9	12.35	1.78
1,000-1,999	1,359.2	242.5	44.0	30.9	26.66	1.96
2,000-4,999	2,960.5	242.3	84.6	35.0	54.02	1.81
5,000-5,999	5,458.9	242.6	177.3	30.8	87.15	1.47
6,000-9,999	7,658.5	247.5	241.0	31.8	121.81	1.42
Truckload						
10,000-11,999	10,857.4	242.5	393.6	27.6	123.88	1.14
12,000-19,999	15,808.8	242.2	522.8	30.2	167.09	0.96
20,000-29,999	23,953.0	242.3	607.0	39.5	213.83	0.89
30,000-39,999	36,237.3	245.6	755.0	48.0	179.41	0.50
40,000 and over	44,049.7	242.7	167.8	262.6	225.75	0.51
All shipments	632.7	242.7	20.3	31.1	11.04	1.72

[a]Common motor carriers of general commodities.

ranged from 26.5 lb in the 0 to 49-lb weight class to 44,050 lb in the over 40,000-lb weight class, the average shipment is 633 lb. This average shipment consists of approximately 21 pieces weighing approximately 31 lb each. The carriers' revenue from the shipment is $11.04 which produces an average rate of $1.72 per hundred-weight.

CTS Example Report Form II

Table 2 gives the reverse of the traffic flow analysis shown in report form I, i.e., these data relate to the movement of goods from Houston to Dallas. Again, the average distance of 242.9 mi, computed for all shipments in this particular traffic flow,

TABLE 2

CTS EXAMPLE REPORT FORM II—TRAFFIC[a] ORIGINATING IN HOUSTON AND DESTINED TO DALLAS

Type of Shipment (lb)	Avg. Wt. per Shipment (lb)	Avg. Distance per Shipment (mi)	Avg. Pieces per Shipment (actual no.)	Avg. Wt. per Piece (lb)	Avg. Revenue per Shipment ($)	Avg. Rate per 100 Lb ($)
0-49	31.5	242.6	2.0	15.8	3.15	10.00
50-99	68.2	242.5	2.7	25.4	3.11	4.56
100-149	118.4	242.4	3.1	38.4	3.95	3.34
150-299	233.5	242.4	6.2	37.4	5.11	2.19
300-499	395.5	242.6	17.2	23.1	7.52	1.88
500-999	694.3	242.4	15.1	45.9	11.63	1.68
1,000-1,999	1,152.5	246.3	36.7	41.5	33.56	2.20
2,000-4,999	3,381.1	243.4	62.4	54.2	62.01	1.83
5,000-5,999	5,723.2	242.5	92.6	61.8	99.96	1.69
6,000-9,999	7,264.0	242.5	127.9	56.8	100.02	1.23
Truckload						
10,000-11,999	10,582.6	242.9	444.6	23.8	168.41	1.41
12,000-19,999	14,632.6	242.8	216.7	67.5	136.23	0.92
20,000-29,999	25,033.5	243.9	471.8	53.1	180.72	0.71
30,000 39,999	33,664.2	247.8	820.4	41.0	192.10	0.56
40,000 and over	42,627.6	244.1	619.8	68.8	190.07	0.45
All shipments	1,454.8	242.9	31.9	45.6	18.15	1.22

[a]Common motor carriers of general commodities.

TABLE 3

CTS EXAMPLE REPORT FORM III—TRAFFIC[a] ORIGINATING IN DALLAS AND DESTINED TO ALL OTHER SMA's WITHIN SOUTHWESTERN REGION

Type of Shipment (lb)	Avg. Wt per Shipment (lb)	Avg. Distance per Shipment (mi)	Avg. Pieces per Shipment (actual no.)	Avg. Wt per Piece (lb)	Avg. Revenue per Shipment ($)	Avg. Rate per 100 Lb ($)
0-49	29.4	308.1	2.2	13.6	3.33	11.32
50-99	69.5	327.1	3.0	23.1	3.50	5.03
100-149	118.6	320.8	4.7	25.2	3.65	3.08
150-299	214.0	323.0	8.8	24.5	5.05	2.36
300-499	381.8	299.5	13.7	27.8	8.46	2.21
500-999	680.1	314.7	20.8	32.7	13.92	2.05
1,000-1,999	1,370.1	342.7	39.2	34.9	29.45	2.15
2,000-4,999	2,969.2	349.7	76.2	39.0	60.86	2.02
5,000-5,999	5,447.7	341.2	109.1	49.9	106.75	1.85
6,000-9,999	7,610.8	373.1	155.1	49.1	130.53	1.63
Truckload						
10,000-11,999	10,839.5	324.4	251.7	43.1	154.70	1.34
12,000-19,999	15,278.8	286.5	313.2	48.8	152.28	0.91
20,000-29,999	23,776.1	325.7	564.0	42.2	198.10	0.82
30,000-39,999	34,685.9	362.5	752.6	46.1	256.43	0.74
40,000 and over	45,082.8	368.8	608.8	74.1	283.66	0.63
All Shipments	516.6	318.7	14.6	35.4	10.00	1.91

[a]Common motor carriers of general commodities.

provides a check on the reliability of the sample data. The average shipment weighs approximately 1,455 lb. The shipment is made up of some 32 pieces weighing slightly less than 46 lb each. Study carriers receive $18.15 for handling the shipment, which represents an average rate of $1.25 per hundred-weight.

CTS Example Form III

Table 3 gives an analysis of shipments originating in the Dallas metropolitan area destined to all other metropolitan areas within the Southwestern Region. As the average distance increases, the average weight of the shipment also increases. Therefore,

TABLE 4

CTS EXAMPLE REPORT FORM IV—TRAFFIC[a] ORIGINATING WITHIN OTHER SOUTHWESTERN REGION SMA's AND DESTINED TO DALLAS

Type of Shipment (lb)	Avg. Wt per Shipment (lb)	Avg. Distance per Shipment (mi)	Avg. Pieces per Shipment (actual no.)	Avg. Wt. per Piece (lb)	Avg. Revenue per Shipment ($)	Avg. Rate per 100 Lb ($)
0-49	29.5	390.6	1.6	18.6	3.85	13.05
50-99	69.5	563.8	2.6	26.7	4.59	6.61
100-149	116.9	520.7	4.1	28.5	4.93	4.22
150-299	213.2	564.2	6.7	31.9	6.85	3.21
300-499	387.0	592.9	11.9	32.6	12.29	3.17
500-999	687.5	580.4	18.5	37.2	19.31	2.81
1,000-1,999	1,423.0	476.7	38.4	37.1	36.60	2.57
2,000-4,999	3,028.5	627.1	62.5	48.4	80.49	2.66
5,000-5,999	5,646.2	494.5	122.0	46.3	149.56	2.26
6,000-9,999	7,772.3	686.5	123.6	62.9	204.20	2.51
Truckload						
10,000-11,999	10,712.9	570.7	294.7	36.4	254.88	2.08
12,000-19,999	15,994.7	531.0	489.9	32.7	275.95	1.51
20,000-29,999	24,545.2	618.9	721.8	34.0	345.46	1.35
30,000-39,999	34,494.5	720.1	899.3	38.4	415.23	1.20
40,000 and over	43.382.8	628.5	857.4	50.6	366.46	0.84
All Shipments	1,329.8	536.0	33.9	39.3	25.57	1.87

[a]Common motor carriers of general commodities.

inasmuch as the average shipment from the Dallas area is moved less than 320 miles, it is not surprising that the average weight of this shipment is only 516. 6 lb. There are less than 15 pieces in this average shipment, with each piece weighing approximately 35 lb. For this service, the carriers receive $10. 00 per shipment, which produces a rate of $1. 91 per hundred-weight of commodity.

CTS Example Form IV

Table 4 gives an analysis of the characteristics of the traffic originating in all metropolitan areas in the Southwestern Region and destined to Dallas. Although there is a tendency for the distance the shipment is moved to increase as the average weight of the shipment increases, the degree of correlation between these two variables is not as significant as that in the form III data. The average weight of shipments is approximately two and one-half times larger than the average form III shipment. Although the form IV average shipment carries approximately the same rate per hundred-weight as the form III average shipment, it moves some 218 miles further, weighs two and one-half times more, and produces approximately two and one-half times the revenue.

Analysis

Data from example report forms I and II support the premise that Dallas is a marketing and distribution center, whereas Houston is considered a heavy industrial area with port facilities available for exporting and importing raw materials. The heavier loading, lower rated traffic moving by common carrier from Houston to Dallas requires significantly different handling techniques and equipment utilization than the lighter loading, higher rated traffic moving from Dallas to Houston. Not only are there more pieces to be handled in the traffic flowing from Houston to Dallas but, in addition, each piece weighs considerably more.

An input-output analysis of traffic originating and terminating in the Dallas metropolitan area gives further support to the premise that Dallas is a market and distribution center. Except for average weight per piece and average rate per hundred-weight, the average inbound shipment to Dallas is approximately two and one-half times larger than the average outbound shipment.

The four example report forms are only a few of the several types of analyses that may be performed from CTS data. With the addition of information, such as commodity classification, cubic space requirements for the shipment, and interchange with other modes, a more detailed evaluation of the characteristics of intercity traffic flow patterns may be conducted.

Secondary data obtained from commercial traffic counts, loadometer data, census of transportation, ICC reports, state highway departments, etc., should provide the necessary interpretive data to make a properly designed CTS program one of the best sources for reliable intercity traffic flow data for the common carrier trucking industry.[13]

If the ability to relate the industrialization of specific metropolitan areas to the growth of marketing and distribution centers throughout the United States is added to these sources of data, a predictive model for accurately estimating the commercial motor carrier's requirements for intercity highways connecting these major metropolitan areas may become a reality.

LIMITATIONS OF THE DATA

The data collected from current sampling procedures is not designed to meet all the requirements suggested in this paper. The principal limitation of the data is directly related to sampling procedures.

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[13]For a discussion of other uses of CTS data see Hoy A. Richards, The Continuous Traffic Study—In Management and Regulation of Motor Carriers, Sixth Annual Meeting of the Transportation Research Forum, New York, New York, Dec. 1965.

Sources of Error

In any study based on data obtained through the statistical technique of sampling, the possibility of error arises, particularly when random sampling techniques are employed. William G. Cochran has identified the three following known sources of error which must be considered when random sampling procedures are used.

1. Failure to measure some of the units in the chosen sample. This may occur by oversight, or with human population, because of failure to locate some individuals or their refusal to answer questions when located.
2. Errors of measurement of a unit. The measuring device may be biased or imprecise. With human population, the respondents may not possess accurate information or they may give biased answers.
3. Errors introduced in editing, coding, and tabulating the results. [14]

W. Edwards Deming classified sampling errors associated with the CTS into three groups. Type I errors or structural limitations in the whole system, may occur when there is a misunderstanding of definitions, e. g., truckload vs less than truckload, or actual weight vs billed weight. Type II errors result from persistent operational blemishes, such as a simple failure of a carrier to subject all of his traffic to the procedure of selection; and transcription errors in rating, such as a carrier's upward or downward scaling of charges associated with a shipment are primary examples of this type of error. Type III errors arise from accidental variations of a compensating nature; these involve accidental errors such as those associated with transcription when a person records a number that does not correspond with the number in the original document. In addition, these errors may arise from sampling variations due to differences in freight bills within a carrier's file. [15]

When processing the volume of data developed from CTS programs, it is impossible to eliminate all such errors. However, properly developed and controlled projects such as this can be successfully carried out with a minimum of errors. The experience gained from current CTS programs will provide invaluable assistance in the establishment of a sampling procedure for a national traffic study.

SUMMARY

The motor carrier Continuous Traffic Study makes available certain statistical information which provides reliable estimates of specific operating characteristics for large groups of motor carriers operating within and between given geographic regions of the United States. Experience gained from the development and institution of CTS in the Southwestern Region suggests that modification of these studies will provide reliable traffic flow data for use in transportation planning and research.

Certain traffic flow analysis reports were compiled from a stratified random sample of approximately 90,000 sampled freight bills. The sample represents a universe of 20 million freight bills prepared during 1965. In addition to a descriptive analysis of intercity freight traffic movement between metropolitan areas, these reports also provide coefficients for use in estimating total movements of goods by common carriers of general commodities between specified standard metropolitan areas.

From data developed from the Southwestern Region CTS, four example report forms were prepared to show the manner by which intercity traffic flow data may be assembled for analysis.

Properly designed and interrelated continuous traffic studies, including statistically selected motor carriers from all regions of the United States, will provide reliable

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[14] W. G. Cochran, Sampling Techniques, John Wiley and Sons, Inc., New York, New York, 1963, p. 355.

[15] For an excellent discussion of these and other possible errors associated with CTS sampling procedures see Dr. W. Edwards Deming, Testimony of Dr. W. Edwards Deming, July 1965, included in I&S Docket No. M-18455 LTL COR Rates - Between East and Territories West, Jan. 1966, p. 9.

information for estimating traffic flow between selected population centers, industrial areas, and marketing regions. Further development of methods used in current CTS programs should produce a family of reports for use in traffic flow analysis. With the addition of secondary data to the family of CTS reports, a predictive model for accurately estimating the commercial motor carrier requirements for intercity highways connecting major metropolitan centers may become a reality.