HIGHWAY RESEARCH RECORD

Number 175

Freight Transportation Economics

4 Reports

Subject Area

15 Transportation Economics

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Washington, D.C., 1967 Publication 1506

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Foreword

Four research papers are presented in this RECORD dealing with freight transportation economics. The first two papers deal with information derived from census material on freight shipments and patterns. The third paper describes the methodology and information being provided by the Southwestern Regional Continuous Traffic Study, and the fourth paper analyzes the importance of transportation in the overall economy.

Donald Church sets forth data gathered on freight volume and characteristics and identifies shipment patterns especially in terms of weight-distance characteristics and intermodal shares. Recent Bureau of Census data indicate that there may be measurable relationships based on weight-distance factors on which intermodal shares of freight traffic might be predicted. The data indicate the greater the distance shipped, the less the reliance on motor freight carrier. Walter Buhl enlarges on this subject and points out the relationship of highway transportation to size of manufacturing plant. As the size of the manufacturing plant increases there is a decreased use by the plant of highway transportation for the shipment of outbound goods.

In response to the statistical needs of the Interstate Commerce Commission, the motor freight industry is developing methods of freight traffic analysis. The paper by Hoy Richards and James Jones describes the design of the Southwestern Regional Continuous Traffic Study of Motor Freight Carriers and the techniques for collecting and computing commodity flow statistics. Reported information includes weight per shipment, average distance traveled, number of pieces, average weight of pieces, average revenue per shipment and average price rate per hundred weight.

The country is very much dependent on highway transportation for a substantial portion of its overall activity. This fact is clearly delineated by Frank Smith, who compares total outlays for transportation to the Gross National Product. Transportation's share of the GNP in 1965 was approximately 20 percent, with highway transportation accounting for about 17 percent. Seventy-three percent of freight dollars and 91 percent of passenger dollars were derived from highway transportation. Out of a GNP of $681 billion in 1965, highway transportation accounted for over $117 billion.

Contents

Impact of Size and Distance on Intercity Highway Share of Transportation of Industrial Products

DONALD E. CHURCH, Chief, Transportation Division, Bureau of the Census

•NEW data from the 1963 Census of Transportation have contributed valuable information concerning an old problem: the distribution of traffic among modes of transport and the extent to which carrier shares are related to readily measurable factors. This paper is concerned primarily with the relationship between highway-carrier share and three basic traffic characteristics: commodity, size of shipment and distance.

The paper discusses the relationships between carrier share and commodity-size-distance factors in terms of the overall situation; it reviews the variations in the highway share associated with one factor at a time—with distance and then with size of shipment. Finally, the paper considers all three factors jointly, discussing variations in highway share for each selected commodity when weight is held constant and distance is allowed to vary.

The data were drawn from the 1963 Commodity Transportation Survey (one of the major projects of the 1963 Census of Transportation) which was based on a probability sample of about one million shipping papers selected from the traffic files of about 10,000 manufacturing establishments that represented essentially the industrial universe of the United States.

Table 1 indicates that highway carriers transported about 42 percent of the total intercity tonnage originating at manufacturing plants. The highway share was split between motor carriers and private trucks, 26 percent by motor carrier and 16 percent by private truck. The non-highway share amounted to about 58 percent of the total, with

TABLE 1

TOTAL TONS OF COMMODITIES ORIGINATED BY MANUFACTURERS, BY MEANS OF TRANSPORT AND LENGTH OF HAUL

Length of Haul (straight-line mi)	Total Tons (millions)	Percent Distribution by Means of Transport[a]						
		Highway			Rail	Air	Water	Other
		Total	Motor Carrier	Private Truck				
Under 50	215	69.1	32.0	37.1	16.9	—	13.1	0.9
50 to 99	185	63.3	34.6	28.7	21.3	—	15.1	0.3
100 to 199	209	54.3	33.8	20.5	33.6	—	11.7	0.4
200 to 299	148	45.7	32.8	12.9	39.8	—	13.9	0.6
300 to 399	96	37.8	29.4	8.4	44.1	—	17.5	0.6
400 to 499	59	36.6	28.5	8.1	55.9	—	6.3	1.2
500 to 599	47	33.6	27.6	6.0	57.3	0.1	8.2	0.8
600 to 799	80	24.7	20.8	3.9	50.8	0.1	23.5	0.9
800 to 999	59	17.3	15.0	2.3	47.4	0.1	34.2	1.0
1000 to 1199	63	6.8	5.7	1.1	21.7	—	70.9	0.6
1200 to 1499	106	2.9	2.5	0.4	12.2	—	84.8	0.1
1500 to 1999	47	6.7	5.9	0.8	41.8	—	50.6	0.9
2000 or more	21	8.0	7.3	0.7	69.5	0.3	20.5	1.7
All distances	1,335	42.1	25.9	16.2	32.8	—	24.5	0.6

[a]Based on a probability sample of about one million shipping papers drawn from the files of about 10,000 manufacturing establishments, 1963 Census of Transportation.

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

TABLE 2

TOTAL TONS OF COMMODITIES ORIGINATED BY MANUFACTURERS, BY MEANS OF TRANSPORT AND SIZE OF SHIPMENT—1963

Size of Shipment (lb)[a]	Percent Distribution by Means of Transport						
	Highway			Rail	Air	Water	Other
	Total	Motor Carrier	Private Truck				
Under 50	42.1	25.5	16.6	2.0	2.8	0.1	53.0
50 to 99	82.5	57.6	24.9	2.6	1.8	0.1	13.0
100 to 199	89.6	65.5	24.1	3.2	1.1	0.1	6.0
200 to 499	92.8	68.6	24.2	3.0	0.5	0.1	3.6
500 to 999	94.1	69.1	25.0	2.5	0.3	0.2	2.9
1,000 to 1,999	94.3	68.9	25.4	2.6	0.3	0.3	2.5
2,000 to 2,999	90.3	64.6	25.7	6.9	0.1	0.4	2.3
3,000 to 4,999	89.9	64.2	25.7	8.3	0.1	0.5	1.2
5,000 to 9,999	92.8	54.1	38.7	4.9	0.1	0.4	1.8
10,000 to 19,999	88.1	43.8	44.3	10.5	—	0.5	0.9
20,000 to 29,999	81.6	53.0	28.6	17.4	—	0.5	0.5
30,000 to 39,999	84.2	56.2	28.0	14.5	—	0.8	0.5
40,000 to 49,999	78.2	57.5	20.7	20.0	—	1.6	0.2
50,000 to 59,999	53.8	35.0	18.8	44.8	—	1.2	0.2
60,000 to 69,999	13.0	8.9	4.1	84.1	—	2.5	0.4
70,000 to 79,999	10.3	7.7	2.6	88.3	—	1.1	0.3
80,000 to 89,999	8.9	6.6	2.3	90.1	—	0.9	0.1
90,000 and over	10.2	6.2	4.0	60.5	—	28.7	0.6

[a]Classifications by size of shipment were based only on weights shown on bills of lading and sales invoices; other shipping source materials (such as tonnage reports) were also used for estimating total tonnage (Table 1) but excluded from tabulations involving shipment size; data derived from 1963 Census of Transportation.

rails accounting for about 33 percent, water for about 25 percent, and all others for less than 1 percent. For some purposes, a more useful overall comparison would be the distribution of total tonnage exclusive of water shipments, which are directly competitive with other modes of transport only between water served origin-destination cities or points. Water carriers also render a service that is substantially different in many other respects. On that basis, the highway share of the total tonnage is about 56 percent and non-highway (almost wholly railroad) is about 44 percent. The relative position of the highway share (excluding water) is probably the most useful average or norm for comparison with the selected commodity tables in this report, because water was not a significant mode of transport for any of these commodities.

As expected, the highway share of the total tonnage (all commodities by all transport combined) tended to be highest for short distances and to decline as distance increased. Although the generally inverse relationship indicated by Table 1 was anticipated, the level of the highway share of long-hauls was probably larger than expected, especially for private trucks.

With respect to size of shipment, three broad weight-bands are significant from the standpoint of highway transport, as indicated by Table 2. Shipments of less than 50 lb move principally by other means of transport—mostly express and parcel post—although the highway share is large, representing 42 percent of the total tonnage of shipments in this size class. The second weight-band starts at about 50 lb and goes up to around 50,000 lb. Highway carriers account for more than 80 percent of the tonnage in all but one of the weight-blocks within that broad range. The third weight-band is about 50,000 lb, in which the highway share drops sharply from 54 percent of shipments in the 50,000-59,999 block to 9 or 10 percent of tonnages in shipments over 80,000 lb.

On a commodity-by-commodity basis, the variations in highway shares are extreme. In the extensive list of commodities shown in the Census Commodity report (1), the highway share ranged from 99.6 percent for ice cream and frozen desserts (TCC 2024)[1] to about 3.1 percent of the tonnage for coke (TCC 33113).

[1]TCC stands for the Transportation Commodity Classification issued by the Bureau of the Budget; it is identical to the Standard Transportation Commodity Classification (through the first five digits) issued by the railroads and motor carriers.

TABLE 3

HIGHWAY SHARE AND AVERAGE LENGTH OF HAUL OF SELECTED COMMODITIES ORIGINATED BY MANUFACTURERS—1963

TCC Code	Commodity[a]	Highway Share (%)		Avg Length of Haul (straight-line mi)	
		Total Tons	Total Ton-Miles	By All Means of Transport	By Highway
228	Thread and yarn	95	85	364	325
307	Misc. plastics products	90	82	793	426
356	General industrial machinery and equipment	83	76	573	527
361	Electrical transmission and equipment	83	68	545	445
265	Containers, boxes and related products	83	64	208	159
349	Misc. fabricated metal products	78	68	388	341
322	Glass and glassware	78	65	268	222
208	Beverages and flavoring extracts	78	43	267	147
382	Measuring and controlling instruments	77	59	796	611
284	Soap, detergents, etc.	75	57	421	320
345	Bolts, screws, rivets, washers, etc.	71	57	338	275
335	Nonferrous metal basic shapes	70	45	535	347
343	Plumbing fixtures and heating apparatus	68	45	666	438
367	Electronic components or accessories	67	57	455	389
201	Meat and poultry (fresh or frozen)	67	51	475	361
233	Women's and infants' clothing	66	58	544	482
365	Radio and television receiving sets	66	48	701	516
339	Misc. primary metal products	58	48	292	243
301	Tires and inner tubes	57	44	567	438
282	Plastics materials and plasticizers	57	35	554	346
289	Misc. chemical products	50	32	397	256
331	Steel works and rolling mill products	41	24	294	175
354	Metal working machinery and equipment	40	47	289	345
363	Household appliances	36	22	699	437
262	Paper (exc. building paper)	35	22	497	309
204	Grain mill products	31	12	325	125

[a]For more complete description of commodities included in each of the TCC Codes, see Commodity Classification for Transportation Statistics issued by the Bureau of the Budget, or Standard Transportation Commodity Code issued by Association of American Railroads.

The highway share for the 26 selected commodities ranged from 95 percent for thread and yarn to 31 percent for grain mill products. The median highway share was about 67 percent. The choice of commodities in the list is a rough cross section of items throughout the entire range of highway participation, except for the extremes. The commodities are listed in order of magnitude of the highway share (Table 3).

The average length of haul by highway was shorter than by all means of transport combined for every commodity (except one), which accounts for the lower level of highway participation on a ton-mile rather than on a tonnage basis.

There seems to be little (if any) relationship between average length of haul and the highway share (Table 3). However, when the distance factor is measured in terms of mileage blocks (rather than a simple average distance), there is a highly significant relationship between highway participation and distance (Table 4). The highway share for each commodity is almost invariably largest for distances of less than 200 miles, and declines as the distance increases. The commodities toward the top of the table tend to remain at a high plateau for longer distances than those toward the bottom.

The corresponding two-dimensional view of commodity and size of shipment is given in Table 5, which indicates a high negative correlation between size of shipment and highway share. But unlike the findings concerning the impact of distance, there seems to be surprisingly little (if any) systematic variation among commodities within size groups. The highway shares for most of the commodities tended to remain high for shipments weighing less than 30,000 lb and in many cases for shipments up to 60,000 lb. The highway share was sharply lower, in most instances, for heavier shipments.

A substantially better view of the impact of size of shipment and distance can be obtained by considering the two factors jointly. Table 6 holds the size of shipment constant (i.e., under 1,000 lb), holds commodities constant (in effect) by listing each commodity on a separate line, and indicates the variation in highway share as distance increases. The median for the 26 commodities for shipments of less than 200 miles was

TABLE 4

HIGHWAY SHARE OF TONS OF SELECTED COMMODITIES ORIGINATED BY MANUFACTURERS, BY MILEAGE BLOCK AND COMMODITY—1963

TCC Code	Commodity	Percent of Total Tons Originated				
		Under 200 Mi	200-399 Mi	400-599 Mi	600-999 Mi	1,000 Mi and Over
228	Thread and yarn	99	99	87	96	42
307	Misc. plastic products	96	94	92	94	63
356	General industrial machinery and equipment	93	88	87	83	77
361	Electric transmission and equipment	97	86	88	80	67
265	Containers, boxes and related products	92	83	64	50	28
349	Misc. fabricated metal products	81	80	74	88	52
322	Glass and glassware	91	72	68	45	14
208	Beverages and flavoring extracts	89	69	44	18	15
382	Measuring and controlling instruments	81	92	79	80	39
284	Soap, detergents, etc.	90	76	63	56	45
345	Bolts, screws, rivets, washers, etc.	89	51	47	81	32
335	Nonferrous metal basic shapes	93	88	74	62	27
343	Plumbing fixtures and heating apparatus	93	94	67	69	21
367	Electronic components or accessories	65	91	67	55	39
201	Meat and poultry (fresh or frozen)	81	81	57	52	37
233	Women's and infants' clothing	76	62	72	64	57
365	Radio and television receiving sets	94	86	66	47	37
339	Misc. primary metal products	64	66	67	36	29
301	Tires and inner tubes	60	72	61	53	31
282	Plastics materials and plasticizers	83	73	59	37	19
289	Misc. chemical products	84	52	31	29	22
331	Steel works and rolling mill products	58	42	31	7	3
354	Metal working machinery and equipment	27	30	36	71	63
363	Household appliances	65	61	29	15	11
262	Paper (exc. building paper)	67	37	27	19	9
204	Grain mill products	58	12	7	6	14

TABLE 5

HIGHWAY SHARE OF TONS OF SELECTED COMMODITIES ORIGINATED BY MANUFACTURERS, BY SIZE OF SHIPMENT AND COMMODITY—1963

TCC Code	Commodity	Percent of Total Tons Originated					
		Shipment Under 1000 Lb	Shipment 1000-9999 Lb	Shipment 10,000-29,999 Lb	Shipment 30,000-59,000 Lb	Shipment 60,000-89,000 Lb	Shipment 90,000 Lb and Over
228	Thread and yarn	95	99	99	84	32	—[a]
307	Misc. plastics products	91	94	93	92	34	24
356	General industrial machinery and equipment	85	89	89	83	74	28
361	Electrical transmission and equipment	86	95	91	73	41	13
265	Containers, boxes and related products	92	98	87	57	57	46
349	Misc. fabricated metal products	90	95	81	85	19	—[a]
322	Glass and glassware	78	73	95	66	1	84
208	Beverages and flavoring extracts	99	96	94	91	4	11
382	Measuring and controlling instruments	76	80	96	8	—[a]	—[a]
284	Soap, detergents, etc.	93	96	90	70	37	83
345	Bolts, screws, rivets, washers, etc.	93	94	76	28	26	—[a]
335	Nonferrous metal basic shapes	94	96	93	75	35	25
343	Plumbing fixtures and heating apparatus	94	96	78	31	14	—[a]
367	Electronic components or accessories	76	92	66	28	—[a]	15
201	Meat and poultry (fresh or frozen)	99	92	77	58	1	13
233	Women's and infants' clothing	63	84	100	100	—[a]	—[a]
365	Radio and television receiving sets	75	80	51	42	—[a]	—[a]
339	Misc. primary metal products	94	98	98	88	37	2
301	Tires and inner tubes	97	98	79	26	19	—[a]
282	Plastics materials and plasticizers	91	95	96	81	15	15
289	Misc. chemical products	93	93	94	67	7	6
331	Steel works and rolling mill products	92	97	95	92	21	4
354	Metal working machinery and equipment	82	90	85	66	17	2
363	Household appliances	84	83	23	15	—[a]	—[a]
262	Paper (exc. building paper)	97	91	82	45	14	9
204	Grain mill products	100	98	92	38	1	1

[a] Either no observations in sample or results for specific cell were too small.

TABLE 6

HIGHWAY SHARE OF SHIPMENTS OF LESS THAN 1,000 LB ORIGINATED BY MANUFACTURERS, BY MILEAGE BLOCK AND SELECTED COMMODITIES—1963

TCC Code	Commodity	Percent of Total Tons Originated				
		Under 200 Mi[a]	200-399 Mi[a]	400-599 Mi[a]	600-999 Mi[a]	1,000 Mi[a] and Over
228	Thread and yarn	98	99	97	96	66
307	Misc. plastics products	96	93	92	92	75
356	General industrial machinery and equipment	91	90	84	81	73
361	Electrical transmission and equipment	91	94	91	74	68
265	Containers, boxes and related products	98	96	92	80	63
349	Misc. fabricated metal products	92	95	93	87	79
322	Glass and glassware	97	88	68	71	54
208	Beverages and flavoring extracts	100	97	98	98	93
382	Measuring and controlling instruments	80	84	78	76	63
284	Soap, detergents, etc.	95	93	91	92	88
345	Bolts, screws, rivets, washers, etc.	96	95	88	86	86
335	Nonferrous metal basic shapes	97	94	94	90	77
343	Plumbing fixtures and heating apparatus	98	96	95	89	90
367	Electronic components or accessories	79	80	80	82	57
201	Meat and poultry (fresh or frozen)	100	100	94	82	64
233	Women's and infants' clothing	70	54	67	60	52
365	Radio and television receiving sets	94	82	80	67	57
339	Misc. primary metal products	96	96	94	88	85
301	Tires and inner tubes	96	97	99	98	92
282	Plastics materials and plasticizers	92	96	88	88	81
289	Misc. chemical products	97	94	92	90	68
331	Steel works and rolling mill products	94	95	90	87	78
354	Metal working machinery and equipment	85	85	78	82	77
363	Household appliances	94	94	88	78	58
262	Paper (exc. building paper)	99	96	96	92	84
204	Grain mill products	100	100	97	95	87
	Median	96	94	91	87	75

[a]Straight-line.

96 percent and decreased gradually up to the 1,000 mile-block. However, despite the tendency to decline with distance, the highway share remained at high levels even for very long hauls.

Tables 6, 7, and 8, reviewed as a series, indicate that the impact of distance is more clearly felt on larger shipments. Table 6 is concerned with small shipments (under 1,000 lb), Table 7 deals with a shipment size-class loosely characterized as truck-load lots (i.e., 10,000 to 29,999 lb) and Table 8 with carload lots (i.e., 30,000 to 59,999 lb). The medians for the 10,000-29,999-lb shipments started at the same high level as for the smaller shipments (96 percent) but declined substantially faster with distance, reaching a low of 49 percent for hauls of more than 1,000 miles. The corresponding figures for 30,000 to 59,999-lb shipments started almost as high (92 percent) for short hauls, but declined much more rapidly as distances increased.

We have concentrated on changes in highway share that seem to be associated with size and distance. Next, the third variable, commodity, is examined to determine how the highway share varies from one commodity to another, when size and distance factors are held relatively constant. Each column in Tables 6, 7 and 8 indicates variations by commodity, when both size and distance are held within specified limits.

Much of that original ranking is indicated in Table 8, which suggests that the highway share for large shipments is dependent not only on size and distance, but that the commodity itself may be an important variable. However, since Table 8 was based solely on large shipments and these same shipments represented a substantial part of aggregates used to measure highway share of the total, a substantial part of this correspondence in ranking is attributable to mathematics and probably not significant with respect to differences in commodity.

A similar ranking of commodities also occurs among shipments in the 10,000 to 29,999-lb range (Table 7). In general, the commodities in which the highway share

TABLE 7

HIGHWAY SHARE OF SHIPMENTS OF 10,000 TO 29,999 LB ORIGINATED BY MANUFACTURERS, BY MILEAGE BLOCK AND SELECTED COMMODITIES—1963

TCC Code	Commodity	Percent of Total Tons Originated				
		Under 200 Mi[a]	200-399 Mi[a]	400-599 Mi[a]	600-999 Mi[a]	1,000 Mi[a] and Over
228	Thread and yarn	100	100	98	100	85
307	Misc. plastics products	96	92	90	97	80
356	General industrial machinery and equipment	87	93	95	91	68
361	Electrical transmission and equipment	100	97	79	86	82
265	Containers, boxes and related products	92	83	69	45	36
349	Misc. fabricated metal products	75	77	92	91	49
322	Glass and glassware	99	95	86	82	6
208	Beverages and flavoring extracts	99	92	94	72	47
382	Measuring and controlling instruments	100	100	100	78	95
284	Soap, detergents, etc.	98	80	89	83	64
345	Bolts, screws, rivets, washers, etc.	84	72	54	87	6
335	Nonferrous metal basic shapes	99	97	94	78	76
343	Plumbing fixtures and heating apparatus	89	98	67	68	35
367	Electronic components or accessories	65	100	72	28	27
201	Meat and poultry (fresh or frozen)	89	95	78	62	49
233	Women's and infants' clothing	100	—	—	—	—
365	Radio and television receiving sets	89	86	42	39	18
339	Misc. primary metal products	99	98	100	98	71
301	Tires and inner tubes	79	84	81	68	74
282	Plastics materials and plasticizers	96	99	96	97	79
289	Misc. chemical products	100	98	76	74	46
331	Steel works and rolling mill products	97	93	95	92	60
354	Metal working machinery and equipment	100	69	68	67	73
363	Household appliances	50	53	17	7	4
262	Paper (exc. building paper)	94	60	67	67	5
204	Grain mill products	97	69	43	50	23
	Median	96	93	86	78	49

[a]Straight-line.

was high tended to remain in the upper brackets for each mileage block, and those which were low generally remained in the lower ranges. However, there seems to be little, if any, systematic variation among commodities when shipped in less than 1,000-lb lots (Table 6).

In brief, this set of tables suggests that size and distance factors account for most of the variability in highway share, with "commodity" becoming a significant third variable, especially for large shipments. Many irregularities in the progressions are indicated. Some may be significantly related to the commodity itself, such as measuring and controlling instruments (TCC 382) and plastics materials and plasticizers (TCC 282) which retained a substantially larger highway share than would be expected from either the share of total or based on size-distance considerations alone. However, most of the irregularities probably reflect sampling variability and other causes for erratic variations normally encountered in small samples.

In conclusion, here is one application of size-distance-commodity factors to the analysis of basic causes of differences in the interregional competitive shares of traffic among rails, motor carriers and private trucks (2). As shown by the Commodity Transportation Survey, highway carriers handled 78 percent of the total tonnage of plastics and plasticizers (TCC 282) shipped by manufacturing plants in New England, but only 26 percent of the total originated by plants in the West South Central states. These figures were based on shipments by rail, motor carrier, and private truck. Shipments by water and other means of transport were excluded, so that the analysis could be concentrated on the three major modes which were (at least potentially) competitive over the full spectrum of origin-destination pairs of points.

In reviewing those interregional differences, the question was raised as to whether they could be explained on the basis of normal size-distance-commodity factors, or if they reflected some significant regional differences from other causes. The percentage

TABLE 8

HIGHWAY SHARE OF SHIPMENTS OF 30,000 TO 59,999 LB ORIGINATED BY MANUFACTURERS, BY MILEAGE BLOCK AND SELECTED COMMODITIES—1963

TCC Code	Commodity	Percent of Total Tons Originated				
		Under 200 Mi[a]	200-399 Mi[a]	400-599 Mi[a]	600-999 Mi[a]	1,000 Mi[a] and Over
228	Thread and yarn	98	94	74	94	28
307	Misc. plastics products	94	97	96	97	52
356	General industrial machinery and equipment	99	30	60	82	89
361	Electrical transmission and equipment	100	49	93	73	59
265	Containers, boxes and related products	67	70	59	34	–
349	Misc. fabricated metal products	94	89	64	78	15
322	Glass and glassware	79	63	59	33	22
208	Beverages and flavoring extracts	99	87	76	57	31
382	Measuring and controlling instruments	–	100	–	–	1
284	Soap, detergents, etc.	86	81	58	42	23
345	Bolts, screws, rivets, washers, etc.	82	13	19	80	11
335	Nonferrous metal basic shapes	94	93	77	71	18
343	Plumbing fixtures and heating apparatus	85	82	33	36	4
367	Electronic components or accessories	37	–	39	17	14
201	Meat and poultry (fresh or frozen)	83	70	56	56	36
233	Women's and infants' clothing	100	–	–	–	–
365	Radio and television receiving sets	100	100	100	16	38
339	Misc. primary metal products	97	97	73	21	67
301	Tires and inner tubes	12	44	31	31	13
282	Plastics materials and plasticizers	94	92	87	62	36
289	Misc. chemical products	92	62	46	49	29
331	Steel works and rolling mill products	98	90	84	40	18
354	Metal working machinery and equipment	92	75	16	72	10
363	Household appliances	54	55	19	14	2
262	Paper (exc. building paper)	59	50	47	33	9
204	Grain mill products	58	20	13	19	39
	Median	92	75	59	42	22

[a]Straight-line.

distribution by tonnage of plastics materials (TCC 282) by type of carrier, by size of shipment, and distance was computed from the Commodity Survey national summaries, in somewhat greater detail than is given in Tables 7, 8 and 9. Those "national normal" factors were then applied to each individual shipment record in the sample for this commodity to estimate the distribution of tonnage that would be expected if every shipment had moved according to the national normal pattern with no variations due to factors other than commodity-size-distance criteria. These anticipated distributions then were tabulated and compared with the actual distributions. Table 9 indicates that nearly all of the interregional variations found in the actual distributions could be attributed to size and distance factors.

These results indicate that long-term estimates of total highway intercity traffic are not merely a function of total output but that size-distance-commodity factors should be taken into consideration. For example, the results suggest that the volume of highway intercity traffic may increase or decrease substantially without a corresponding change in total output or demand for products. For example, a trend toward larger shipments (such as through extensive containerization and use of freight-forward services that are able to consolidate small shipments into large lots) should tend to shift traffic from the highways to rail. However, a trend toward small consignments (e.g., "hand-to-mouth buying" to minimize inventories) would be expected

TABLE 9

ACTUAL VS ANTICIPATED CARRIER SHARES OF PLASTICS MATERIALS BY ORIGIN AREAS

Origin Area (census divisions)	Highway Share (%)		Rail Share (%)	
	Actual	Anticipated	Actual	Anticipated
New England	78	76	22	24
Middle Atlantic	75	74	25	26
East North Central	60	61	40	39
South Atlantic	74	76	26	24
East South Central	62	65	38	36
West South Central	26	31	74	69

to increase highway tonnage. Shorter hauls, such as caused by the migration of plants to locations nearer markets, would tend to increase the intercity highway tonnage, except for possible offsets to the extent that the plants' markets become local and are removed from the intercity segment.

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Intercity Highway Transport Share Tends To Vary Inversely With Size of Plant

WALTER F. BUHL, Assistant Chief, Transportation Division, Bureau of the Census

Small manufacturing plants, as a general rule, depend primarily on highway transportation for their shipments to customers or redistribution points. The degree of reliance tends to decline with an increase in size of plant.

The focal point is the significant inverse relationship between size of manufacturing plants and their relative use of highway transport for outbound shipments, as shown by an analysis of a probability sample of over one million shipments drawn from the traffic files of about 10,000 manufacturing plants, representing essentially the industrial universe of the United States.

The prime applications appear to be for improving long-range estimates of highway potentials arising from changes in industry-plant-size mix and for estimating market potentials for industry-area categories that could not be published in the Commodity Transportation Survey reports.

•THE data in this paper were drawn from the 1963 Census of Transportation. The central concern is the relationship between the highway-carrier share of tonnage and the characteristics of the shipper. Two shipper characteristics were used: size of manufacturing (i. e., shipping) establishment and industrial classification of the plant.

The number of production employees in an establishment was used as the measure of size. Employment, rather than tonnage of intercity shipments or value of total production at the plant, was used for several reasons. Employee-size class was available in Census records for almost all establishments in the entire "universe" before sampling and was used as a basis for stratification; consequently, it was readily available for the following analysis. Detailed statistics are published showing the number of manufacturing establishments by employee-size class for each industry (Standard Industrial Classification at the 4-digit level) in each county (2). This presents a useful universe to derive area or industry estimates not shown by published traffic or production data, provided that reasonably useful traffic factors can be developed for application to those establishment counts.

Tonnage as a measure of establishment size for transportation studies would clearly be the best, if available. However, tonnage was not known for most individual plants before the survey. After processing the data, it would be possible to estimate tonnage-size class of the plants in the sample, on the basis of the reported sample of shipments. However, there would be no universe figures (such as number of plants by employee-size class) for subsequent applications.

The value of total production is on record (at the time of the last Census of Manufactures or more recently for some plants) and could be used to classify plants by size. However, detailed universe data, such as are available on plant size, cannot be released without violating statutory limitations concerning disclosure of activities of individual plants or companies. Consequently, transportation factors tied to value-based plant-

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

TABLE 1

SHIPPER GROUP SUMMARY—MEANS OF TRANSPORT
(Tons of Shipments)[a]

Shipper Group	Tons (thousands)	Distribution by Means of Transport (%)						
		Rail	Motor Carrier	Private Truck	Air	Water	Other	Unknown
1 Meat and dairy products	39,787	27.1	29.8	42.6	—	0.1	0.3	0.1
2 Canned and frozen foods and other food products	125,726	59.9	21.6	17.4	—	0.7	0.1	0.3
3 Candy, beverages, and tobacco products	44,249	22.3	29.8	45.7	—	1.9	0.2	0.1
4 Textile mill and leather products	12,609	13.5	65.3	19.0	0.1	0.1	1.8	0.2
5 Apparel and related products	3,906	9.3	62.0	11.2	0.8	—	16.3	0.4
6 Paper and allied products	65,551	49.9	33.1	13.9	—	1.9	1.0	0.2
7 Basic chemicals, plastics materials, synthetic rubber and fibers	79,916	54.2	23.4	9.5	—	12.3	0.4	0.2
8 Drugs, paints, and other chemical products	60,318	42.0	34.8	19.9	0.1	2.2	0.6	0.4
9 Petroleum and coal products	398,066	8.0	10.2	7.9	—	73.5	0.4	—
10 Rubber and plastics products	8,884	25.4	63.4	8.7	0.2	0.3	1.8	0.2
11 Lumber and wood products, except furniture	70,380	53.7	14.4	29.7	—	2.1	0.1	—
12 Furniture, fixtures, and miscellaneous manufactured products	9,494	22.4	39.8	35.5	0.1	0.4	1.5	0.3
13 Stone, clay and glass products	175,597	30.1	35.8	28.1	—	5.9	—	0.1
14 Primary iron and steel products	120,521	52.8	36.4	4.1	—	6.3	0.3	0.1
15 Primary nonferrous metal products	18,862	51.5	33.9	11.0	—	2.9	0.3	0.4
16 Fabricated metal products, except metal cans and miscellaneous fabricated metal products	16,298	22.5	42.8	31.7	0.1	0.5	1.9	0.5
17 Metal cans and miscellaneous fabricated metal products	12,787	27.1	55.4	15.0	0.2	0.9	1.2	0.2
18 Industrial machinery, except electrical	5,876	21.0	65.0	8.2	0.5	1.1	3.3	0.9
19 Machinery, except electrical and industrial	14,130	37.0	50.6	9.7	0.3	0.2	1.9	0.3
20 Communication products and parts	2,391	22.2	56.2	9.0	2.8	0.4	9.1	0.3
21 Electrical products and supplies	10,106	34.0	49.5	13.4	0.2	0.4	2.2	0.3
22 Motor vehicles and equipment	34,717	51.2	42.2	5.7	0.1	0.2	0.4	0.2
23 Transportation equipment, except motor vehicles	3,242	35.5	38.9	21.7	0.7	0.8	2.0	0.4
24 Instruments, photographic equipment, watches and clocks	1,423	13.3	69.8	8.4	1.2	0.2	7.0	0.1
United States, total	1,334,838	32.8	25.9	16.2		24.5	0.5	0.1

[a]Data derived from 1963 Census of Transportation, Commodity Transportation Survey, Shipper Groups, TC63-C1. Bureau of the Census, Transp. Div.

size classes would have less flexibility for general application in future market and transportation studies.

The second shipper characteristic is the industrial classification of the plant. As the total sample involved only 10,000 establishments, the 1963 Survey classified the industrial universe into 24 broad industrial classes called shipper groups. The sample contained roughly 400 plants in each of the shipper groups, which form the basic statistical framework of this paper.

What is the relative importance of each shipper group as a highway traffic generator? Highway carriers transported about 42 percent of the total tonnage of all products (Table 1). Table 2 indicates that the highway share varied greatly among shipper groups, ranging from 84 percent for the textile mill and leather products group to 18 percent for the petroleum and coal products group. Only 3 or 4 groups (out of the 24 listed in Table 2) had lower highway participation than the 42 percent mentioned previously for the total of all industrial tonnage. These 3 groups were petroleum and coal products, basic chemicals, and canned and frozen foods. On the borderline were primary iron and steel products and lumber and wood products.

Small manufacturing plants, as a general rule, depend primarily on highway transportation for their shipments to customers or redistribution points. The degree of reliance on highway transport tends to decline with an increase in size of the plant. Inasmuch as this paper is concerned with the relationship between highway-shares and shipper characteristics, the median has been adopted as a more useful measure of central tendency than the arithmetic average. In those terms, about half of the 24 industry

TABLE 2

HIGHWAY SHARES OF TOTAL TONS SHIPPED BY MANUFACTURING PLANTS, BY SHIPPER GROUP AND EMPLOYEE SIZE[a]

Rank		Shipper Group	Highways (% of total)	Highway Share (%)			
				Under 20 Employees	20-99 Employees	100-499 Employees	500 & Over Employees
1	4	Textile mill and leather products	84	91	94	88	78
2	24	Instruments, photographic equipment, watches and clocks	78	45	80	87	73
3	3	Candy, beverages, and tobacco products	76	99	91	72	67
4	12	Furniture, fixtures, and miscellaneous manufactured products	75	92	92	78	51
5	16	Fabricated metal products, except metal cans and miscellaneous fabricated metal products	75	98	87	82	46
6	5	Apparel and related products	73	80	80	80	49
7	18	Industrial machinery, except electrical	73	93	95	82	59
8	1	Meat and dairy products	72	97	79	78	53
9	10	Rubber and plastics products	72	93	93	84	63
10	17	Metal cans and miscellaneous fabricated metal products	70	98	75	73	61
11	20	Communication products and parts	65	93	92	85	57
12	13	Stone, clay and glass products	64	99	76	60	49
13	21	Electrical products and supplies	63	98	93	79	50
14	23	Transportation equipment, except motor vehicles	61	81	57	81	47
15	19	Machinery, except electrical and industrial	60	96	91	57	57
16	8	Drugs, paints, and other chemical products	55	91	67	45	39
17	22	Motor vehicles and equipment	48	92	97	87	44
18	6	Paper and allied products	47	82	80	63	21
19	15	Primary nonferrous metal products	45	89	87	46	38
20	11	Lumber and wood products, except furniture	44	56	56	31	26
21	14	Primary iron and steel products	41	91	79	49	38
22	2	Canned and frozen foods and other food products	39	75	37	40	31
23	7	Basic chemicals, plastics materials, synthetic rubber and fibers	33	21	72	32	26
24	9	Petroleum and coal products	18	67	76	35	9
		Median	63	92	84[b]	76	48

[a]Data derived from Bureau of the Census, Transp. Div.
[b]Based on average of 3 observations above and below median point because of wide gap.

groups shipped more than 63 percent of their total tonnage by highway, whereas the other half shipped less than that proportionate amount. The median for small plants (under 20 employees) was 92 percent, with only 4 shipper groups showing less than 75 percent by highway.

Moving to the next larger plant size, the median declined to about 84 percent, with only 5 groups showing less than 75 percent by highway. Of the 24 groups, 14 showed a decline in the highway share as compared with smaller plants, 4 showed no change with size and 6 showed a reverse tendency.

Moving to the next larger plant size (100 to 499 employees), the median declined to 76 percent, and the range of variation among shipper groups substantially widened. The industries at the top of the list remained generally in the 80's and those toward the bottom of the list were generally in the 30's and 40's. The median dropped to 48 percent for the large plants (500 or more employees) and varied over a wide range, from a top of 78 percent for textile mill and leather products to a low of 9 percent for petroleum and coal products. The highway share of traffic for large plants was lower than for all plants (combined) in each shipper group, without exception. The generally downward progression in the last column of Table 2 from top to bottom seems systematically to reflect the progression of highway share for the industry group, in column 1. Much of that similarity is undoubtedly purely mathematical, because plants with 100 or more employees account for the bulk of the total tonnage. In fact, plants with 100 or more employees accounted for 90 percent or more of the total tonnage in 6 shipper groups, and from 70 to 90 percent in 14 others, leaving only four shipper groups in which plants in this broad-size class accounted for less than 70 percent of the total.

As shown by Church (1), the highway share of the tonnage for most commodities was inversely related to distance shipped. This probably is one of the major causal factors

TABLE 3

AVERAGE STRAIGHT-LINE MILES FROM MANUFACTURING PLANT TO DESTINATION OF SHIPMENT, BY SHIPPER GROUP AND PLANT SIZE[a]

	Shipper Group	Total (mi)	Distance (mi)			
			Under 20 Employees	20-99 Employees	100-499 Employees	500 & Over Employees
1	Meat and dairy products	400	143	314	367	586
2	Canned and frozen foods and other food products	392	267	299	437	510
3	Candy, beverages, and tobacco products	308	102	196	319	389
4	Textile mill and leather products	513	392	444	416	621
5	Apparel and related products	559	327	576	549	620
6	Paper and allied products	410	207	189	317	566
7	Basic chemicals, plastics materials, synthetic rubber and fibers	455	185	308	415	546
8	Drugs, paints, and other chemical products	384	207	274	393	654
9	Petroleum and coal products	689	408	167	368	818
10	Rubber and plastics products	518	464	478	434	565
11	Lumber and wood products, except furniture	590	149	539	782	1077
12	Furniture, fixtures, and miscellaneous manufactured products	471	228	307	465	694
13	Stone, clay and glass products	159	91	126	161	219
14[b]	Primary iron and steel products	282	334	392	305	276
15	Primary nonferrous metal products	585	295	308	595	620
16	Fabricated metal products, except metal cans and miscellaneous fabricated metal products	376	136	302	350	537
17	Metal cans and miscellaneous fabricated metal products	364	133	296	419	361
18[b]	Industrial machinery, except electrical	477	568	385	518	462
19	Machinery, except electrical and industrial	614	412	430	628	639
20[b]	Communication products and parts	643	1197	564	638	640
21	Electrical products and supplies	593	678	417	511	640
22[b]	Motor vehicles and equipment	457	480	317	461	461
23	Transportation equipment, except motor vehicles	446	198	470	476	422
24	Instruments, photographic equipment, watches and clocks	713	638	778	712	705
	Median		311	314	468	526

[a]Data derived from Bureau of Census, Transportation Div.
[b]Shipper groups in which average length of haul apparently does not vary with size of plant.

for the apparent inverse relationship between highway share and size of plant. For example, the average length of haul for all shipments (all means of transport combined) by the meat and dairy products shipper group (Table 3) is 143 straight-line miles for plants having less than 20 employees, and increases with plant size to 586 miles for large plants. The highway share for that shipper group starts at 97 percent for the small plants and drops to 53 percent for the largest establishments. The median for all shipper groups is about 311 mi for small plants, which increases to 526 mi for large plants. This is associated with a change in highway share from 92 percent for smallest to 48 percent for the largest plant-size class.

TABLE 4

RAIL, MOTOR CARRIER, AND PRIVATE TRUCK SHARES OF TOTAL TONS SHIPPED BY MANUFACTURING PLANTS, BY INDUSTRIAL GROUP AND EMPLOYEE SIZE[a]

Mode of Transport and Industrial Group	Tons (%)			
	Under 20 Employees	20-99 Employees	100-499 Employees	500 & Over Employees
Rail				
Paper and allied products	15	18	36	73
Petroleum and coal products	33	21	17	4
Primary iron and steel products	5	19	49	54
Motor carrier				
Paper and allied products	21	52	44	18
Petroleum and coal products	36	32	19	6
Primary iron and steel products	68	46	42	35
Private truck				
Paper and allied products	61	29	19	4
Petroleum and coal products	30	43	16	3
Primary iron and steel products	23	34	7	3

[a]Corresponding data for each of 21 other industrial groups can be developed from Tables 10, 1963 Census of Transportation, Commodity Transportation Survey, Shipper Groups, TC63-1.

The distance component is calculated by a computer program known as PICADAD. Distance is the straight-line miles between the origin and destination shown on the shipping paper, without allowance for circuity in actual route used by the carrier. Straight-line distances are less than rail short-line miles or highway direct-route distances. One the average, railroad short-line and highway direct-route miles exceed the calculated straight-line miles by about 24 and 21 percent, respectively.

A more detailed analysis that would simultaneously involve shipment size and distance would probably help to resolve some of the variations that seem to be out of line with the distance factor alone. A further refinement of shipper groups into more homogeneous classes, such as the subgroups used in the 1963 Survey, probably would reduce the heterogeneous nature of broad industry categories and help to identify causal elements more definitely. However, this goes beyond the scope of this paper, but may be a good area for later research based on the results of the 1967 Survey, now nearing the end of its planning stage.

The strong inverse relationship between plant size and highway transport share (Table 2) has a counterpart in rail share for two out of the three industry groups indicated in Table 4. In those two groups, rail and highway handle all except a small part of the total shipments. The pattern for the other group (petroleum and coal products) is different principally because water carriers handle about 74 percent of the total and are especially dominant on long hauls by large shippers.

A comparison of the apparent relationships between plant size and highway participation (Table 2) with corresponding data for motor carriers and private trucks (Table 4) suggests that prime causal factors underlying the division of traffic between the for-hire and private trucks differ from those affecting the relative shares by rail and highway. We do not know at present what they are, and suggest that this is another potentially good area for further study.

In summary, there is a substantial inverse correlation between the highway-carrier share of total tons originated by manufacturing establishments and plant size. The level of the highway share for any given size of plant varies from one shipper group to another. These relationships should prove useful for judging the probable direction of change in highway requirements for intercity transportation of industrial output, when applied to forecasts of probable change in size of plant within the various broad industrial groups.

With respect to applications, these relationships between plant size and transport requirements could be used to improve data needed for long-range planning, especially for issues involving the probable effects of changes in the relative distribution of plants by size class. For example, even without any change in total production or location of plants or markets, a significant change in highway transport volume would be expected from changes in the size-mix of industrial facilities. A trend toward consolidating the output of many small plants into a single large plant would be expected to reduce significantly the tonnage moving by highway. Decentralization of output apparently would tend to increase highway transport requirements.

Perhaps the most promising application is the use of factors based on these data in conjunction with the Census of Manufactures for estimating traffic potentials for many areas, industry classes and possibly commodities for which data could not be published, either because the figures would disclose activities of individual companies, or the sample of traffic data was not large enough to support such details. Although the Census of Manufactures could not publish specific data on the number of employees, value of shipments, and other measures for each county-industry category, the Census does publish a count of the number of manufacturing plants, classified by state, county, industry, and employee-size class. The joint use of those counts of manufacturing plants with traffic flow information from the Commodity Transportation Survey is a potential method for roughly estimating the transportation volume for industry groups and areas that could not be shown in the Census of Transportation reports. Estimates based on broad factors, of course, may be subject to serious errors, but could be a substantial improvement over the present alternatives, provided these estimates are tempered by judgment and reviewed for reasonableness.

Other applications such as use in market strategy planning by carriers, may also develop. The traffic data classified by industry-group and plant-size, when coupled with plant-counts by industry-size-area categories could be used not only to estimate total traffic potential, but also to compute approximate quotas by mode of transport.

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

HOY A. RICHARDS, Associate Research Economist, Texas Transportation Institute, Texas A & M University, and
JAMES D. JONES, JR., Marketing Specialist, Southern Minerals Corporation

•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.

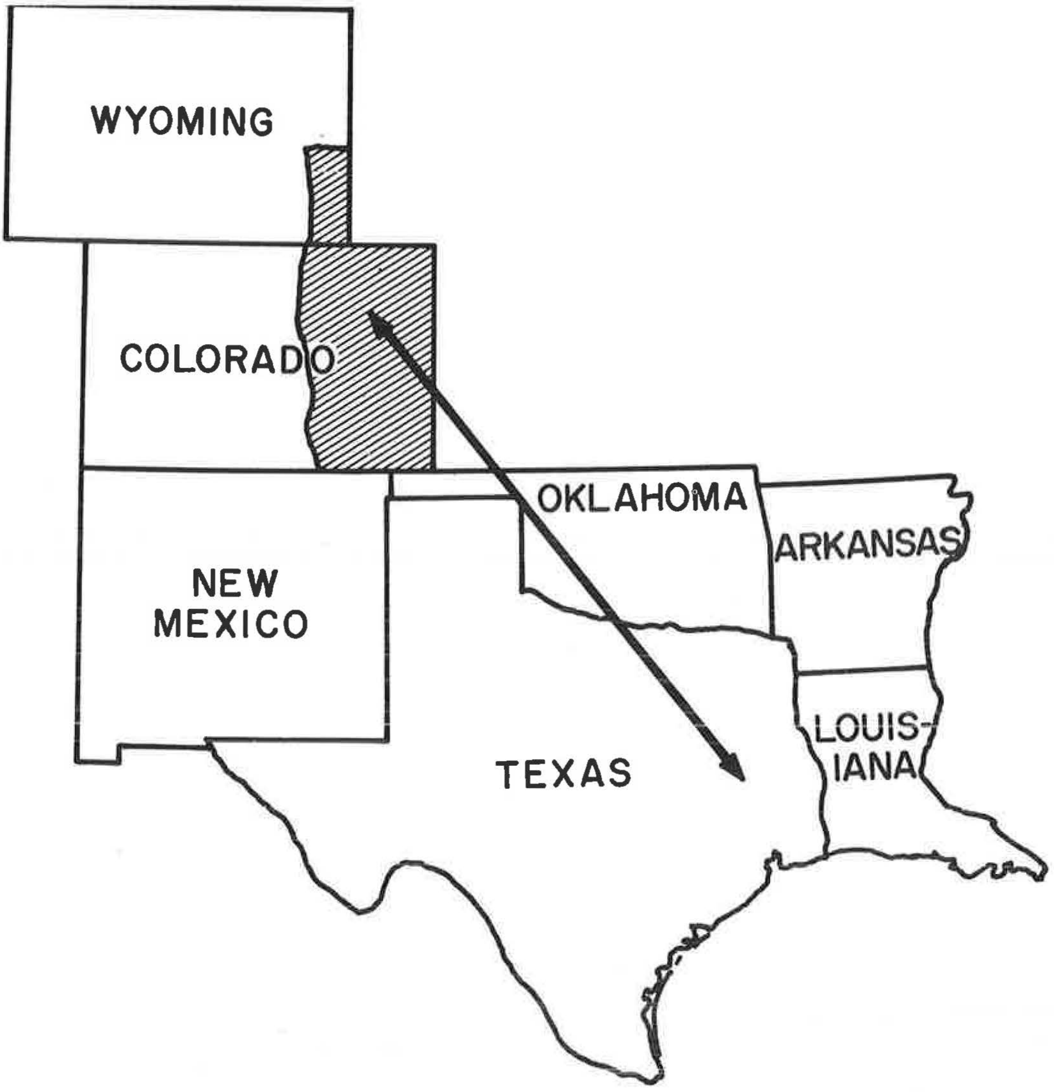

Figure 1. States included in Southwestern Region.

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.

GENERAL OFFICE COPY

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).

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

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

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 →

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.

[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.

Relative Role of Highway Transport in the U. S. Economy

FRANK A. SMITH, Vice President—Research, Transportation Association of America

•AS a researcher for a national transportation policy organization, I have a somewhat different approach to transportation statistics than most persons who develop and analyze such statistics. My approach does not develop data that will enable individual carriers to make detailed market analyses or provide information largely for use at the operational level by carriers and shippers.

The primary purpose of the statistical work conducted by the Transportation Association of America (TAA) is to define the role of the overall transportation function in the nation's economy and to compare the relative roles of the various modes, including highway carriers. Development of such information over an extended period of years enables us to determine basic trends in the transport field. Such information is necessary for the study of national transport policy issues and it assists directly in the policy decision-making process.

MEASURING TRANSPORT'S ROLE IN THE U. S. ECONOMY

Before discussing the relative role of highway transport in the U. S. economy, it is necessary to refer to TAA's statistical estimation of the relative role of transportation as a whole in the nation's economy. In this instance, transportation is considered as a function, as opposed to an industry, and it encompasses not only for-hire carriage, but also private freight and passenger carriage, including the family automobile.

The gross national product is used as a common measure of the U. S. economy, although it is intended to be used for analyzing broad economic trends, rather than for showing absolute values. The objective is to determine with reasonable accuracy the portion of the GNP that can be attributed to transportation of one kind or another, and then to determine highway transport's share.

The usual way that economists look at the construction of the GNP is by the so-called value added, or input, approach. This involves the determination, for each industry classification, of the sum of compensation of employees' and proprietors' income, rental income, corporate profits, and inventory valuation adjustment, plus net interest. The total of these values represents national income, to which are added indirect business taxes and capital consumption allowances to equal the GNP.

It would be virtually impossible to attempt to find transportation's share of the GNP by this approach. Although the value added figures can be obtained for the regulated for-hire transport industry, its share of total transportation outlays is actually dwarfed by the value added that can be attributed to private carriage by manufacturing firms.

For example, the petroleum industry operates many tankers, private pipelines, barges, tank trucks, and even business aircraft which, combined, undoubtedly represent a sizable share of the national income value for that industry, but which cannot be determined without extensive and costly analysis. Add to this other heavy private transportation users such as the steel, retail food, and construction industries, and it is easy to see why this approach cannot be applied.

The expenditure, or output, method of constructing the GNP involves the addition of personal consumption expenditures, government purchases of goods and services, gross

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

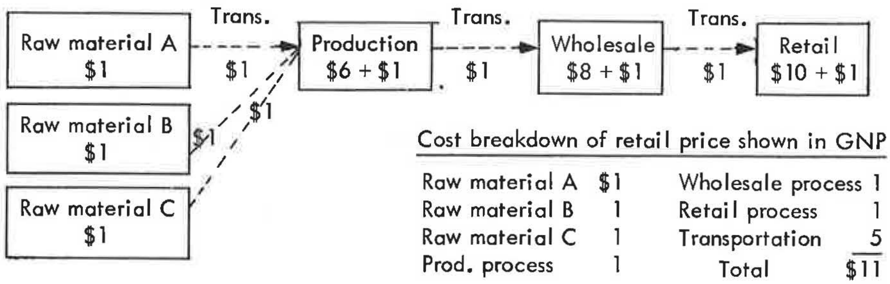

Figure 1. Simplified diagram.

private domestic investment, and net exports of goods and services. By using this practical method, it is possible to determine and, where necessary, estimate the transportation outlays involved in these components of the GNP. As care must be taken, in making comparisons with GNP, not to include so-called intermediate values of products sold at retail, it was necessary to insure that the inclusion of all transport costs was appropriate. Using a simplified diagram (Fig. 1), we concluded that each stage of transportation represented an unduplicated cost directly included in the final retail prices used in computing GNP. For purposes of this analysis, we can assume that the processing cost, including profit, at each stage of total product flow is $1.00 and that each separate transportation movement costs $1.00.

Although the foregoing figures are oversimplified and could be subject to refinement, they appear basically sound and thus make it statistically valid to compare total transport costs with the GNP. Therefore, we can use transport operating revenues of for-hire carriers and estimated operating costs of private carriers as a means of tabulating transport's share of the GNP.

ROLE OF TRANSPORT IN THE U. S. ECONOMY

Detailed explanations of how these transport revenues and costs are derived are obtainable from many sources, with a fair amount of estimating to help fil the statistical gaps.

Using 1965 figures, TAA developed an estimated national freight bill of $62.6 billion and a passenger bill of $78.1 billion. After several adjustments were made to eliminate duplications such as the freight costs for new automobiles and to add government expenditures for transport facilities not covered by direct user outlays, the total transportation bill amounted to $140.5 billion, or 20 percent of the GNP of $681 billion for 1965. This approximately 20 percent share of GNP for transportation remained relatively stable throughout the 1958-1965 period, despite some rather sizable changes within the various modes of transport.

HIGHWAY PASSENGER SHARE OF GNP

Auto outlay figures in the officially reported personal consumption expenditures can be used to estimate highway transport's share of the GNP. However, these figures represent personal auto outlays only, and do not include the costs of automobiles used by business. The latter must be taken into account because they are part of the cost to business of providing goods to the consuming public. To make this adjustment, it is necessary to increase the reported auto expenditure figures by approximately 18 percent.

A similar problem arises for for-hire highway passenger transport, and the reported personal consumption figures have to be "blown up" about 5 percent for local bus and 29 percent for taxi outlays. In the case of intercity bus lines this problem is avoided by using revenues reported by the carriers themselves.

These highway passenger expenditures yield the following estimates for 1965.

Auto	$67,787 million
Local bus[a]	1,345 million
Taxi	855 million
School bus	643 million
Intercity bus	700 million
Total	$71,330 million

[a]Includes transit, but not broken down.

The national passenger bill was previously estimated at $78.1 billion; the highway share of this amounts to 91.3 percent, which in turn is 10.5 percent of the 1965 GNP of $681 billion.

HIGHWAY FREIGHT SHARE OF GNP

With regard to highway freight transport cost, there is a large information gap. Operating revenues of ICC-regulated trucking companies are reported, although comparable data for non-ICC-regulated intercity and local trucking are not obtainable. However, some basic figures are available from which estimates can be made for these areas.

The only figures available for intercity trucking are estimated ton-miles of non-ICC-regulated intercity carriers, i.e., those not subject to ICC economic regulation. Carriers in this category include private, exempt for-hire, and regulated intrastate carriers. Collectively, they account for a little more than 64 percent of total intercity truck ton-miles.

As there are no available accurate cost figures for the millions of trucks of various sizes and weights constituting this 3-part segment of intercity trucking, the only recourse is to use a broad average cost figure. Such a figure for ICC-regulated trucks is obtainable, although the average revenue per ton-mile, rather than the average cost per ton-mile, must be used because we are interested in the total transport cost to the final consumer of the goods hauled by truck.

The question can be raised whether the cost of regulated trucking service to users is more than private and exempt trucking service. As to the actual comparative level of average costs, we assumed that the non-ICC carriers' transport costs were $0.01 a ton-mile lower than the ICC carriers' average revenue per ton-mile. This was reasonable because of the probable higher costs of ICC-regulated carriers that are the result of rate regulation, the need for more extensive terminal facilities, and common carrier obligations such as performing marginal services. However, we assumed that the annual changes in average costs of the two groups vary in the same proportion, because both categories are subject to union wage demands and changes in the price of equipment and gasoline.

For local trucking, the task is even more difficult because there are no overall average cost figures available. The TAA approach is to start with urban truck vehicle-mile figures reported by the U. S. Bureau of Public Roads. We then take figures reported by the General Services Administration of average cost, excluding driver costs, per vehicle-mile of GSA trucks, applying weight factors to the different size trucks in line with the relative number of total trucks in the U. S. For instance, we used a weight factor of 8 for trucks of one ton or less and a factor of 3 for 1 to $2\frac{1}{2}$-ton trucks. To obtain an estimate for driver costs per vehicle-mile, we used a figure of $0.15 for the base year 1958; this figure was justified by an ICC study indicating that in that year drivers' wages averaged more than $0.15 per mi on extremely short-haul traffic. To keep the $0.15 per veh-mi driver costs from rapidly becoming outdated, it was adjusted each year in proportion to the percentage of change in union drivers' wages as reported by the Department of Labor.

The final highway freight figure covers the movement of small packages and mail by intercity bus companies, which can be estimated from figures reported to the ICC.

These highway freight expenditures were used to make the following estimates for the year 1965.

Intercity truck	
ICC regulated	$ 9,994 million
Non-ICC regulated	15,872 million
Local truck	19,889 million
Bus	68 million
Total	$45,823 million

The estimated national freight bill was $62.6 billion, so the highway share of this amounts to 73.2 percent, which in turn is 6.7 percent of the 1965 GNP of $681 billion.

TOTAL HIGHWAY TRANSPORT SHARE OF GNP

These highway passenger and freight estimates, when combined, show that, from a monetary standpoint, highway transportation clearly dominates the U. S. transport scene.

Passenger Expenditures		Freight Expenditures	
Auto	$67,787 million	Intercity truck	
Local bus	1,345 million	ICC regulated	$ 9,994 million
Taxi	855 million	Non-ICC regulated	15,872 million
School bus	643 million	Local truck	19,889 million
Intercity bus	700 million	Bus	68 million
Total	$71,330 million	Total	$45,823 million
	Grand total	$117,153 million	

Inasmuch as TAA estimates that $140.5 billion was spent during 1964 for all types of for-hire and private transportation, the $117 billion attributed to highway transportation amounts to 83.4 percent, or more than four-fifths of the total transportation bill. The $117 billion highway transportation bill alone accounted for 17.2 percent of the $681 billion GNP for 1965.

HIGHWAY INTERCITY FREIGHT TON-MILE SHARE

Inasmuch as trucks, in general, haul relatively high-value commodities at much higher average rates than bulk carriers such as railroads, pipelines, and water carriers, the use of money values as a means of measuring the relative role of highway freight could be challenged as overstating the importance of this mode. The most commonly used measure for making modal comparisons is ton-miles, which reflects both weight of the commodity and the distance it travels. These figures are obtainable from the ICC, although the Commission's basic tables do not include domestic deep-sea ton-miles, and therefore overstate the relative share of the other modes. The basic ICC ton-mile tables for 1964 (the only complete figures available) give the following breakdown.

Mode	Ton-Miles (billions)	Percent
Rail	666	43.3
Truck	350	22.8
Oil pipeline	269	17.5
Water	250	16.3
Air	1.5	0.1
Total	1,536.5	100.0

The trucks' share is nearly 23 percent. However, a more accurate breakdown can be obtained by incorporating the ton-miles of off-shore domestic water carriers (1964) not included in the foregoing table, as follows.

Mode	Ton-Miles (billions)	Percent
Rail	666	37.5
Truck	350	19.7
Oil pipeline	269	15.2
Water	487	27.5
Air	1.5	0.1
Total	1,773.5	100.0

Although the resulting reduction in the highway share from 22.8 percent to 19.7 percent is not too great, there is a sharp contrast in the use of money values vs ton-miles for measuring the relative size of modes of transport. This can be shown by using the intercity portion of TAA's estimated national freight bill for 1964, which amounts to $35.2 billion after eliminating local and international freight outlays, and comparing it with intercity highway freight outlays of $23.3 billion. This shows highway's share as 66.2 percent.

HIGHWAY INTERCITY PASSENGER-MILE SHARE

The use of a monetary vs passenger-mile measure for comparing highway transportation's role with that of other modes will not show such large differences in the intercity passenger field, because the automobile dominates this field, regardless of the measure selected. For example, the auto alone accounted for 89.6 percent of total intercity passenger-miles, with the bus lines accounting for another 2.5 percent, to make highway's share 92.1 percent.

Although TAA's estimated auto expenditure figure is not broken down into intercity and local, the former can be assumed to be 50 percent, in line with the U. S. Bureau of Public Road's breakdown for rural vs urban auto vehicle-miles in 1964. Thus, we can use $30.2 billion for intercity auto expenditures, plus $671 million for intercity bus outlays, for a total of $30.9 billion for intercity highway passenger transport in 1964. This represents 86.8 percent of a total intercity passenger bill of $35.6 billion.

COMBINATION WEIGHT-DISTANCE-VALUE MEASUREMENT

Although it may not be strictly valid from a statistical standpoint, it should be interesting to see how the various modes of intercity transport compare when all three factors of load (tons/passengers), distance, and monetary value are combined. Table 1 gives a breakdown of intercity freight transportation for 1964.

TABLE 1

RELATIVE ROLE OF INTERCITY FREIGHT MODES GIVING EQUAL WEIGHT TO TON-MILES AND COST OF TRANSPORT

Mode	Ton-Miles (billions)	(a) Percent	Cost (billions)	(b) Percent	(a) + (b)	$\frac{(a) + (b)}{2}$
Rail	666	37.5	$ 9.1	25.9	63.4	31.7
Water	487	27.5	1.4	4.0	31.5	15.8
Highway	350	19.7	23.3	66.2	85.9	42.9
Pipeline	269	15.2	1.0	2.8	18.0	9.0
Air	1.5	0.1	0.4	1.1	1.2	0.6
Total	1,773.5	100.0	$35.2	100.0	200.0	100.0

TABLE 2

RELATIVE ROLE OF INTERCITY PASSENGER MODES GIVING EQUAL WEIGHT TO PASSENGER-MILES AND COST OF TRANSPORT

Mode	Passenger-Miles (billions)	(a) Percent	Cost (billions)	(b) Percent	(a) + (b)	$\frac{(a) + (b)}{2}$
Auto	802.0	89.6	$30.2	84.8	174.4	87.2
Bus	22.7	2.5	0.7	2.0	4.5	2.2
Air	49.5	5.5	4.1	11.5	17.0	8.5
Rail	18.4	2.1	0.5	1.4	3.5	1.8
Water	2.8	0.3	0.1	0.3	0.6	0.3
Total	895.4	100.0	$35.6	100.0	200.0	100.0

There is a problem, in making such a comparison, of how much weight to give to the ton-mile vs the cost factors. Although transport statisticians may argue about their relative merits, each is given equal weight for the sake of simplicity. The result is the column at the right (Table 1), which shows the relative share of highway intercity freight transportation as nearly 43 percent. This lies halfway between its 20 percent share of total intercity ton-miles and 66 percent share of total intercity freight outlays.

Table 2 gives a breakdown for intercity passenger transportation for 1964.

It is clear that regardless of the measure used, highway transportation, because of the automobile, dominates the intercity passenger field.

CONCLUSION

In summarizing, we can first estimate that transportation's share of GNP is approximately 20 percent, with highway transportation accounting for about 83 percent of this figure. In other words, highway transportation's share of the GNP is more than 17 percent.

In terms of monetary values, highway transportation also dominates both the freight and passenger fields, accounting for more than 73 and 91 percent, respectively, of the total outlays in each category.

In terms of intercity ton-miles only, highway transportation's share of the total traffic drops to approximately 20 percent, although it collects over 67 percent of the money spent for such transportation. On a basis of equal weight given to ton-miles vs expenditures, highway transportation accounts for about 43 percent of the total.

In terms of intercity passenger-miles, regardless of how relative values are measured, highway transportation dominates the scene, with only air transportation taking any sizable share.

Any way these figures are adjusted, the conclusion remains that this country is very dependent on highway transportation for a large portion of its overall economic activity.