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

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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from changes in industry-plant-size mix and for estimating market potentials for industry-area categories that could not be published in the Commodity Transportation Survey reports.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-

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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 nonferroue 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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