

# Freight Flow and Attitudinal Survey for Arizona

A. ESSAM RADWAN, MUSHTAQR RAHMAN, AND SYLVESTER A. KALEVELA

A mail survey of randomly selected carriers was used to collect data about freight flows on Arizona's primary and secondary highways and about carriers' perceptions of certain freight related problems. The data obtained included commodities shipped, tonnage, origins and destinations, Arizona routes used in the travel, and attitudinal information on several transportation issues and concerns. The route-specific freight flow information was needed to run a simulation model that had been developed for the Arizona Department of Transportation. The sample was drawn as a three-stage stratified random sample of 2,100 carriers from a prepared list of population of 12,900 carriers (16.28 percent sample size). The rationale for using the mail survey technique, the design of survey forms, the procedures used in follow-up, and the various strategies adopted to achieve better response rate are described. A summary of some of the data analysis results is given. The survey results indicate that Interstate highways are the routes most used for freight movements in Arizona. Furthermore, the attitudinal questions revealed that carriers consider insurance costs to be their major future concern and pavement condition to be the most significant problem that may affect the trucking industry.

The Arizona Department of Transportation (ADOT) recently realized that there was a need for a planning model to evaluate the performance of Arizona's highway system for freight movement. In response, the Arizona Freight Network Analysis (AFNA) research project was undertaken in February 1986 (1). Data collection for the project was accomplished with a self-administered survey that was designed to gather data on highway freight movements and carrier attitudes toward certain issues related to freight transportation. The goals, methodology, design, sampling plan, and results of the survey are presented in this paper.

The data collection vehicle selected for the AFNA project was a mail survey with multiple follow-ups. The focal points of this data collection effort were freight movements on and carrier attitudes about the Arizona highway network. The data on highway freight movements were necessary to drive a network-type simulation planning model that had been developed as part of the AFNA project to simulate freight traffic flow on Arizona highways. Attitudinal data from the carriers were required as part of an effort to understand the respondents' perceptions of various freight issues and concerns. The survey

instrument was therefore designed with two parts: a freight movement survey (FMS) and a carrier attitudes survey (CAS).

Before the decision was made to conduct the self-administered survey, secondary data sources were investigated for possible use in data compilation. The commodity flow data provided in the current census reports of the Commodity Transportation Survey were found to be too aggregated for application in a state-level freight analysis, especially for a simulation model that requires freight movement information in terms of intercity trips and by commodity groups. In addition, the census reports provided information only on manufacturing and related industries.

In previous efforts to develop a data base for nationwide commodity flows on the basis of 173 Bureau of Economic Analysis (BEA) economic areas, it was noted that there were no independent data sources that could provide a measure of flows of individual commodities carried by trucks between the BEA economic areas (2, p. 233). This lack of disaggregated commodity flow data for the highway mode poses a difficulty in freight modeling. Reebie and Associates of Greenwich, Connecticut, have developed a national freight data base called Transearch (3) that contains intercity freight traffic flows. The existing summary reports for Transearch did not meet the requirements of the AFNA model, however. The possibility of getting special tabulations from the Transearch data base was examined and found to be too expensive because the process would involve extensive programming tasks for the vendor.

Some of the computer-readable data bases, like Wharton Econometric and DRI, were also examined. These data bases do not provide the necessary data for flow modeling either: they mainly contain international financial and credit statistics and macroeconomic data.

Given this background, the AFNA researchers believed that it was necessary to employ survey research methods for data collection. The main reason for selecting mail survey as the collection method was its cost-effectiveness and convenience when compared to an on-the-road intercept survey at ports of entry. Moreover, the intercept survey method is not suitable for capturing "internal-internal" trips, which are intercity movements by carriers within the Arizona state boundary.

The mailed surveys were addressed only to freight carriers, mainly because of the type of freight movement data that were required for the simulation model. The AFNA

model needed route-specific origin-destination (O-D) data on commodity flows. Shippers and receivers are not likely to have route specific O-D data on commodity flows. Because carriers are directly involved in hauling goods on the roads, they generally maintain such information. Also, because the goal of the AFNA project was to evaluate the performance of the Arizona highway system, the carriers' responses to the attitudinal questions were considered more important than those of shippers or receivers.

The issue of nonresponse bias—that is, the bias associated with nonrespondents who voluntarily do not participate in the survey—was not examined empirically in this research because all of the traditional methods for dealing with nonresponse bias have been demonstrated to have significant disadvantages (4, p. 37). Instead, multiple follow-up procedures were undertaken to achieve a better response rate and thereby reduce the nonresponse bias.

### SAMPLING PROCEDURE

The researchers selected 2,100 carriers to receive survey questionnaires. A random stratified sampling technique was applied to the total population of 12,900 carriers, ranked by the total annual miles driven in Arizona. Thus a relatively large sample size (16.28 percent) was drawn for the survey. The population list was prepared with 1985 tax accounts data from the ADOT Motor Vehicle Division (MVD). The stratified sampling plan that was used in the survey was as follows:

- Top 1,200 carriers (1,200 sampled, or 100 percent),
- Carriers from 1,201 to 1,900 (350 sampled, or 50 percent), and
- Carriers from 1,901 to 12,900 (550 sampled, or 5 percent).

### SURVEY METHODS

#### Mail-Back Questionnaire

After the attributes of the mail survey were considered in relation to the precise survey objectives, scattered carrier population to be surveyed, and budgetary constraints, a mail-back questionnaire technique with multiple follow-up procedures was chosen to collect data on freight movements and carrier attitudes. A comprehensive literature review of mail surveys and response rates can be found elsewhere (5).

In the survey that was used for the AFNA project, sampling was performed from a prepared population list. This may have introduced some bias in the representativeness of the sample. That is, each unit of the population may not have had an equal opportunity of being included in the sample. Efforts were made to overcome this problem by

- obtaining the latest information available (for example, the list of carriers that was gathered from MVD was current as of January 1985), and

- minimizing the duplication of carriers in the list (for example, one out-of-state carrier may have local offices in Phoenix, and both offices may be listed with MVD for accounting purposes; only one office was included in the final list).

One problem in conducting mail surveys is that of selection of appropriate respondents. This problem arose in the current study because the sampling units were business firms or other organizations for which there were no available contact names. As a result, the first wave of questionnaires was directed to the attention of "Transportation Director," and the follow-up mailings were sent to the president of the firm (by title). This procedure was chosen under the assumption that the surveys would be passed on to the appropriate person within the target company.

Because the sampling list contained freight carriers that were located all over the United States, the mail questionnaire was probably the best method for reaching all the respondents. Another advantage was that no additional cost was incurred in contacting respondents who had moved to a new location and left a forwarding address.

#### Survey Strategies

The first mailing package contained six items. The first page was a cover letter typed on Arizona State University letterhead, signed by two university faculty members. Because no contact names were available for the target firms, the letter began impersonally, with "Dear Sir." The letter was carefully worded to explain to the respondents the goals and benefits of the survey and to assure them of the confidentiality of the data that were requested. The carriers were asked to provide commodity shipment information for a "recent representative week" of 7 days. The second page was the instruction sheet, which contained some hypothetical examples to assist respondents in filling out the forms. The third page was the freight movement survey form, and the fourth page was a duplicate copy of the same. The fifth page was the attitudinal survey.

The 7-day period for the representative sample should not be misconstrued as the sample size. It actually characterizes the sample period. This characterization was considered important in determining truck traffic variation within a week. Also, it was determined that a request for data for periods longer than a week would reduce the survey return rate.

#### Follow-Up Procedures

##### *Second Wave of Questionnaires*

The second wave of questionnaires was sent out to the group that did not respond to the first wave. Minor revisions were made to the original FMS form to clarify a few

- making the list relevant (for example, the original MVD list of 13,049 carriers was brought down to 12,900 by sorting for passenger carriers and leasing firms),

issues that appeared to cause confusion, judging from the first returns. For example, the explanation “(total weight of vehicle + commodity)” was provided after the “Gross Weight” heading. The only major change made to the CAS form was the addition of more items to the list of “current and future concerns and problems.”

The second mailing was conducted with a change in survey sponsorship. Arizona Motor Transport Association (AMTA) letterhead was used for the cover letter, which was signed by the Executive Vice President. This change was meant to increase the interest of the respondents and emphasize the importance of the surveys.

### *Third Wave of Questionnaires*

The forms used in the third wave were identical to the second wave forms. The survey sponsorship was changed to make the survey instrument more authoritative. In this wave, the cover letter was sent by the Transportation Planning Division of the Arizona Department of Transportation. Although the carrier code was not included in the forms, as it had been in the first two waves, the cover letter requested the respondents to write the code on the returned form. It was decided that the code was not critical at this point because no additional follow-up effort was planned.

### *Telephone Calls*

After mailing out the third wave of questionnaires, telephone calls were made to the Arizona-based carriers that belonged to the “top 200” group of the sampling plan. The decision to make this follow-up effort was mainly based on availability of financial resources and the importance of the work to Arizona highway network usage. The phone calling was time consuming and difficult to pursue because of the lack of contact names. People in the higher echelon of company management, like the vice president or president, were not available most of the time, and lower-level executives were hesitant to take any responsibility. Even so, many successful contacts were made with these larger carriers. These contacts were helpful in encouraging the carrier company representatives to respond to the survey, even though response involved a large effort for them in terms of record and data base sorting and summarizing.

## **DESIGN OF SURVEY FORMS**

### **Freight Movement Survey (FMS)**

The goal in designing this form was to make it precise and simple, yet capable of capturing the important data needed for the study. The freight movement survey form requested information on the following:

- carrier code,
- contact person,

- date,
- carrier type,
- shipping date,
- commodity shipped,
- gross weight,
- shipment's origin city and state,
- shipment's destination city and state,
- Arizona routes taken in travel, and
- comments.

### **Meetings with Carriers**

As part of the design process for the survey forms, several visits were made to meet with representatives of various types of carriers. The goals of the meetings were to make contacts with the operating personnel and get their suggestions and reactions to a proposed form and data collection procedures, reaffirm the researchers' understanding of operating procedures of carriers in the Phoenix area, and learn more about the availability of automated data within the industry. The on-site visits covered six different categories of carriers:

- common carriers of general freight that serve both interstate and intrastate traffic,
- common carriers of general freight that serve primarily interstate traffic,
- private carriers that serve both interstate and intrastate,
- common carriers of specific commodities and general freight that serve primarily interstate,
- private carriers of special commodities that serve Arizona only, and
- private carriers of food products that serve Arizona primarily.

The following facts emerged from the visits:

- Specific statistical information would generally be available from existing records or computerized data bases, with some adjustments or additions needed from other records in some instances.
- Most carriers would be hesitant to supply information unless they were assured of its confidentiality.
- Specific shipment or trip weights are usually estimated or averaged. Individual truckloads are not weighed because the weight-distance tax forms allow reporting by weight classification.
- Weight data are not usually recorded into data bases but could be determined from invoices or loading reports.
- Route-specific data are available because most carriers schedule a given number of trips from an origin city to various destinations in a given time period on a given route. For those cases in which specific schedules were not available, O-D data could be derived from shipping documents.

As a result of the visits, the researchers came to the following conclusions:

- To maintain confidentiality, the survey form should not contain names and addresses of carriers; a code would be used instead.

- The form should not ask for mileage between origins and destinations because supplying such data would only complicate the reporting process and would merely reflect map miles, which are readily available by use of a state highway map.

- The tonnage data available would not be strictly accurate but would be adequate for modeling.

- Route-specific data would be available from for-hire carriers but could only be approximated for truckload and special commodity carriers. Also, route-specific data over city streets would not be available and were outside the scope of this research.

### Carrier Attitudes Survey (CAS)

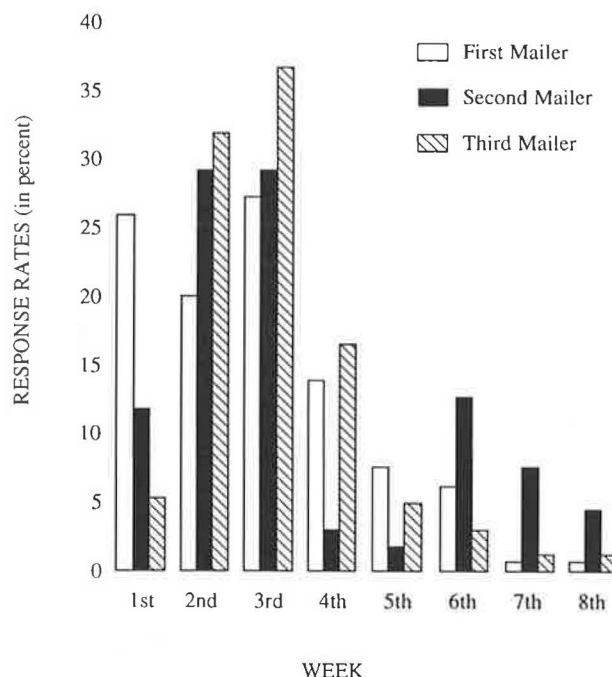
The CAS questionnaire contained both questions in multiple-choice format with ranking and questions in "yes/no" answer format. The five questions used in the CAS section covered the following topics:

- issues that adversely affect the operation and safety of the carrier (e.g., geometric design, pavement condition, etc.),
- seasonal variations in carrier operations,
- current and future concerns in the transportation industry (e.g., insurance, labor issues, public safety, etc.),
- primary carrier markets (e.g., farms, manufacturing, wholesale and retail trade, etc.), and
- interfaces with other carriers modes (rail, air, pipelines, or water).

### RATE OF SURVEY RETURNS

Figure 1 shows weekly return rates for the three waves. It can be seen that the weekly rate of return increases during the first three weeks, then decreases, to become almost nonexistent by the end of the seventh week. The timing for mailing the second and the third waves was determined on the basis of having reached a negligible rate of return (the eighth week, as can be seen in the figure).

Table 1 presents a summary of response rates by wave for the two surveys. The table also shows the number of "genuine" nonresponses found in the survey. The genuine



**FIGURE 1** Weekly response rates of the three mailing waves.

nonresponses include carriers that had gone out of business or packages that were sent back due to change of address or incomplete address. This type of nonresponse is called "genuine" because "it can be assumed generally to be a random or quasi-random occurrence that adds no significant bias to the survey data" (4, p. 35). As a result, these nonresponses were subtracted from the sample size for calculation of response rates. The other kind of nonresponses, called "nongenuine," usually introduces bias in the survey data (6). The nongenuine nonresponses include carriers whose representatives declined to participate in the survey (with or without specifying a reason), carriers whose surveys were returned blank or incomplete, and carriers whose representatives did not respond at all.

It can be noted from the table that a response rate of 25 percent was achieved in three waves for the freight movement survey and a rate of 28 percent for the carrier attitudes survey. If the two surveys are treated as a single survey entity, the response rate is computed to be 29 percent. Table 1 also presents the effect of follow-up efforts and survey sponsorship on the overall response rates. It is evident from the results that the follow-up efforts were effective. The ADOT sponsorship may be one reason for the relatively higher response rate in the third wave.

**TABLE 1** RESPONSE RATES BY MAILING WAVE

	First Wave		Second Wave		Third Wave		Three Waves Combined	
	Number of Responses	Percent of Sample	Number of Responses	Percent of Sample	Number of Responses	Percent of Sample	Number of Responses	Percent of Sample
Freight Movement Survey	147	7.5	109	5.5	229	11.6	485	24.6
Carrier Attitudes Survey	145	7.3	147	7.5	256	13.0	548	27.8

NOTE: Respondents ( $R$ ): freight carriers; population: 12,900 carriers; sample:  $S = 2,100$  carriers; sampling technique: stratified random sampling; genuine nonresponse:  $G = 127$ ; percentage of response:  $P = 100 [R/(S - G)]$ .

## ANALYSIS OF SURVEY DATA

### Freight Movements Survey (FMS) Data

In this section, the results of statistical analysis on several types of data are presented.

#### *Trip Calendar*

Most of the first data sample was recorded in September and October. The second data sample was from November and December, and the third data sample was from January and February. There is likely to be bias in the results because of the time of year that the data were collected. This was anticipated in the study, and the time period was selected because it was considered typical. Future data may need to be examined closely for any peak or off-peak behavior during the year.

The data indicated that freight movement occurs on all 7 days of the week. Most trips occurred during the weekdays, and they were distributed roughly uniformly over the business week. Saturdays had about 50 percent and Sundays 25 percent of the number of trips recorded during a weekday. This finding suggested the inclusion of weekend activity in the simulation model.

#### *Carrier Type*

Roughly 20 percent of the trips recorded were of unspecified carrier type, 26 percent were common carrier, 24 percent were for-hire carrier, 21 percent were private carrier, and 8 percent were contract carrier.

#### *Commodity Type*

The data indicate that the manufacturing and agricultural commodity groups were most prevalent and that mining, services, and unclassifiable were least. It appears that extrapolation based on these data may be statistically supportable. The unclassifiable code is not recorded often, and the distribution appears to be filled out. Additional data would help to determine the appropriateness of scaling and forecasting these data.

#### *Gross Weight*

It was observed that roughly 50 percent of the trucks weighed between 75,000 and 85,000 pounds. A few higher values (for multiple-axled vehicles) were also recorded. The extremely low values that were recorded represented net weight instead of gross weight and have been modified by adding a typical vehicle tare weight.

### *Origins and Destinations*

Trips that originated outside Arizona were coded with ports of entry into Arizona as their origin cities, and trips terminating outside Arizona were coded with exit ports as their destination cities. This coding scheme was adopted to place boundaries on the Arizona highway network that was to be used in the freight traffic simulation. The five cities used as ports of entry into Arizona (Lupton, San Simon, Yuma, Ehrenberg, and Topock) make up the majority of the trip origins and destinations. This further emphasizes the use of the state highways for through trips. Most of the other trips recorded in the survey are from major cities in Arizona, such as Phoenix, Tucson, and Flagstaff. Many small cities have no originating or terminating trips at all. From statistical analysis, it is evident that extrapolation cannot be performed with these data in their present form. Data for major cities may be satisfactory, but data for smaller cities and highway junctions do not have sample sizes large enough to allow proper statistical extrapolations.

#### *Route Use*

It was observed that Interstate highways in Arizona are the most heavily used for freight movements. Many of the other routes had no trips recorded in the survey data. The sample size of the route use data is too small, and additional data are needed for proper use. This problem could be addressed by using a smaller highway network that consists of the Interstate highways.

The collected survey data set is characterized by directional flow of truck traffic. Attempts to correlate this data set with highway traffic counts failed because the available average daily traffic counts are of mixed vehicular composition and do not provide directional flow (7).

### Highway Carrier Attitudes Survey (CAS) Data

#### *Trucking Operation and Safety Issues*

Table 2 summarizes the responses obtained for the questions on trucking operation and safety issues, ranked in order of importance according to the responses. It can be observed that almost 24 percent of respondents listed inadequate highway geometric design as the most important problem, and 30 percent considered this to be a problem that may affect their trucking operations. The problem of bad pavement condition appeared to be most critical, given that 53 percent of the respondents listed this problem as most important, and 5 percent mentioned it as the second most important. Only 6 percent of the respondents considered inappropriate location of intermodal terminals to be one of their concerns. This last result was expected because few of these carriers are involved with intermodal freight

TABLE 2 TRUCKING OPERATION AND SAFETY ISSUES

Issues	Responses (%)	Breakdown of Responses in Order of Importance (%)				
		1 <sup>a</sup>	2	3	4	5
Inadequate highway geometric design standards	30	24	4	2	—	—
Bad pavement condition	58	53	5	—	—	—
Inappropriate location of intermodal terminals	6	4	1	1	—	—
Stop areas needed for fatigued drivers	18	11	4	2	1	—
Inadequate warning sign system	13	8	3	1	1	—
Other <sup>b</sup>	13	12	1	—	—	—

<sup>a</sup> Most important.

<sup>b</sup> Examples of "others": not specified; conditions are fine; bridge decks misaligned and abutting too rough pavement; more freeways needed; lack of truck stops with service facilities between San Simon, Wilcox, and Tucson; use of off ramps and signal lights instead of cloverleafs; left turn signals needed.

operation in addition to their common or for-hire operation.

Only 17 percent of all the respondents indicated that their operations interface with other modes of transportation (air, rail, and pipeline). The remainder operate independently. In addition, 68 percent of all respondents stated that their operations had no seasonal variations, and 31 percent mentioned variations.

#### Current and Future Concerns in the Transportation Industry

Table 3 presents a summary of the responses about current and future freight concerns. The first column lists the issues that respondents were to rate according to importance and whether the issues were of concern to the transportation industry. The second column presents the rate of affirmative responses.

TABLE 3 CURRENT AND FUTURE CONCERNS IN FREIGHT TRANSPORTATION

Current and Future Concerns	Responses (%)	Breakdown of Responses in Order of Importance (%)				
		1 <sup>a</sup>	2	3	4	5
Insurance	86	74	9	2	1	—
Labor issues	7	4	1	1	1	—
Public safety	34	24	6	3	1	—
Tax collection	40	23	11	4	2	—
Economic conditions	45	30	5	7	3	—
Government control	35	26	5	3	1	—
Bad vehicle conditions	22	16	2	2	2	—
Bad drivers	37	27	4	4	2	—

<sup>a</sup> Most important.

Responses. Respondents were asked to attach an index of importance to each affirmative response. An index of 1 indicates issues that were rated as the most or among the most important concerns, whereas an index of 5 index indicates issues of least importance. Among the respondents, 86 percent stated that insurance was among their current and future concerns. Of these 86 percent, 74 percent noted that insurance was among their most serious concerns, 9 percent rated it as second most important, 2 percent believed that insurance was a third-level concern, and only 1 percent rated it as a fourth-level concern. The rate of affirmative responses for the rest of the issues in the list is given in the second column of the table.

#### Commodity Hauled

Table 4 summarizes the results obtained for this query. On the basis of the total number of returned survey forms, the column of responses (second column) gives the proportion of carriers who haul a given commodity. For instance, farm produce is transported by some 20 percent of all carriers. The order of importance in column three indicates whether a given commodity is hauled as a primary, secondary, or tertiary item. For example, of the 20 percent of the carriers who haul farm produce, 18 percent stated that farm produce is their primary cargo.

#### CONCLUSIONS

The combined response rate of the first, second, and third waves amounted to 25 percent for the freight movements survey and 28 percent for the carrier attitudes survey. From

TABLE 4 COMMODITIES HAULED BY CARRIERS

Commodity Hauled	Responses (%)	Breakdown of Responses in Order of Importance (%)				
		1 <sup>a</sup>	2	3	4	5
Farms	20	18	1	1	—	—
Mining	6	5	1	—	—	—
Agricultural services, forestry, and fisheries	13	12	1	—	—	—
Construction	18	17	1	—	—	—
Manufacturing	28	25	3	—	—	—
Transportation, communications, and utilities	4	4	—	—	—	—
Wholesale and retail trade	37	33	3	1	—	—
Finance, insurance, and real estate	1	1	1	—	—	—
Services	5	4	1	—	—	—
Government	4	3	1	—	—	—
Other <sup>b</sup>	20	20	—	—	—	—

<sup>a</sup> Most important

<sup>b</sup> Examples of "other": food products, livestock, U.S. Postal Service, garbage, freight of all kinds, chemicals and petroleum products in bulk, hazardous waste, caskets, liquid asphalt and asphalt products, scrap metal, records/tapes/videotapes, paper, not specified.

a statistical analysis of the freight movements survey data, the following conclusions were drawn.

- Although weekend freight trips are less frequent than weekday, the weekend activity needs to be included in simulations of freight traffic on Arizona highways.
- About 50 percent of the trucks traveling on Arizona highways weighed between 75,000 and 85,000 pounds.
- Haulage of agricultural, construction, and manufacturing commodities dominates freight transportation in Arizona.
- Five ports of entry and several major cities in Arizona were almost the only locations given as trip origins and destinations.
- Freight movements in Arizona occur primarily on Interstate highways.

The following conclusions were drawn from the carrier attitudes survey.

- Bad pavement condition received the highest concern rating from the carriers, followed by inadequate highway geometric design standards.
- Insurance costs, economic conditions, tax collection, bad drivers, government control, and public safety are the current and future concerns of the freight carrier industry.
- Freight transported on Arizona highways consists mainly of commodities related to wholesale and retail trade.
- Most of the carriers surveyed do not have seasonal variations in their trucking operations.

## ACKNOWLEDGMENTS

This paper was prepared as a part of the study "Arizona Freight Network Analysis," which was funded by the Ari-

zona Department of Transportation. The authors duly acknowledge the cooperation, support, and guidance of Hari Khanna of the Transportation Planning Division. They also wish to acknowledge the work and assistance provided by other members of the project team, namely Jeffrey Cochran, Martin Farris, Ming Tsu Chen, and Li Lin.

## REFERENCES

1. A. E. Radwan et al. *Arizona Freight Network Analysis, Volume 1, Freight Flow Information*. Final report. Center for Advanced Research in Transportation, Arizona State University, Tempe, 1987.
2. Jack Faucett Associates, Inc., *Freight Commodity Flows, 1972*. Final report. Transportation Systems Center, U.S. Department of Transportation, 1977.
3. *Transearch*. Reebe and Associates, Inc., Greenwich, Conn., 1982.
4. P. R. Stopher and I. M. Sheskin. Method for Determining and Reducing Nonresponse Bias. In *Transportation Research Record 886*, TRB, National Research Council, Washington, D.C., 1982, pp. 35–41.
5. L. Kanuk and C. Berenson. Mail Surveys and Response Rates: A Literature Review. *Journal of Marketing Research*, Vol. 12, 1975, pp. 440–453.
6. W. Brog and A. H. Meyburg. Consideration of Nonresponse Effects in Large-Scale Mobility Surveys. In *Transportation Research Record 807*, TRB, National Research Council, Washington, D.C., 1981, pp. 39–46.
7. *Traffic on the Arizona State Highway System, 1986*. Transportation Planning Division, Arizona Department of Transportation, Phoenix, 1986.

---

*The views expressed in this paper are those of the authors and not of the Arizona Department of Transportation.*

*Publication of this paper sponsored by Committee on Freight Transportation Planning and Marketing.*