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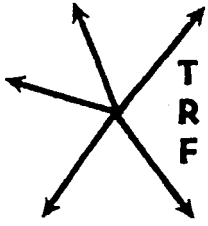

TRANSPORTATION RESEARCH FORUM

Shippers' Preferences for Trucking Services: An Application of the Ordered Logit Model

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INTRODUCTION

IN DECIDING how to design and market service strategies for motor carriers, information on the relative importance of service attributes is highly useful. This information can provide guidance on which attribute to emphasize, e.g., should a carrier provide low rates or highly reliable service in an attempt to attract and maintain customers? Another important question is how large a market share can be attracted by particular service strategies?

These considerations are especially important in the new competitive environment resulting from the Motor Carrier Act of 1980 and the Staggers Act. In an attempt to maintain or expand their market shares, many carriers have instituted price discount programs. However, other strategies emphasizing service attributes other than price may be more effective. The ordered logit model can be used to measure the relative importance of price to other service attributes and, therefore, provide insight into effective marketing strategies.

The ordered logit model is a method that 1) produces information on the relative importance of product or service attributes in the selection of alternative products or services and 2) uses this information in estimating market shares for alternatives. In the market share analysis, both existing or new alternatives can be considered, e.g., a carrier may want to analyze the market potential of offering a price discount versus emphasizing its safety record.

Price discount strategies treat motor-carrier service as a commodity product. A commodity product is one which over time has become so well accepted and fixed in the minds of the consumer that the providers cannot differentiate between their offerings to attract market share except on the basis of price alone.

Interestingly, it seems like only a few years ago, shippers said price was not important. Now it seems like it is the only thing that is important. At that time the motor-carrier product was not very price differentiated and the shippers were looking for points of product differentiation. The result was that the carriers pushed themselves to provide more service for the price they were charging. These extremely high levels of service became the accepted standard. Given the nature of the motor-carrier industry and its technology, it became too expensive to give less service. Given the present state of excess capacity in the industry, it is relatively easy to give very responsive service.

Following deregulation, if we do not have the ability to change the nature of the motor-carrier product, the industry is doomed to compete on a commodity basis—that is, price only. Under current industry conditions we have excess capacity in motor carriage chasing too little freight.

The only way to gain market share in a commodity market is to slash prices to every carrier's loss. The low-cost producers, the firms with staying power due to large war chests, and the "savages" are the likely survivors of such competition. We suggest that competition based upon additional service attributes other than price is healthier for the industry as a whole.

As we entered the period of greater regulatory freedom, the industry had a number of ideas about how and why people bought the motor-carrier service product. The product concept seemed well defined. The industry understood what "common carriage" and "contract carriage" were. The industry understood what "regular-route" and "irregular-route" carriers were. We suspect, however, that the customer was understood in a very narrow way because we really had very little experience of how shipper behavior would change if the shipping environment shifted substantially. These product concepts that were so clearly understood were really the ways the ICC and the industry defined the motor-carrier product. Traffic managers had to go to school to learn to speak this product language, but they only used these terms because providers of the service did. When they spoke to other managers, including their own executives, they spoke more of "satisfying needs," "providing services," "cost/

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benefit analysis," and other concepts. They generally felt that the motor-carrier definitions and views of the world were artificial and annoying. So, the first step in shaping the new motor-carrier product is to put away our old concepts and terms and start learning the shippers' views.

A market research perspective, of which ordered logit can be an extremely useful tool, is an essential element in deriving these new service strategies.

ORDERED LOGIT MODEL

The ordered logit model is a refinement of the multinomial logit model which is well-known in transportation research, especially passenger transportation (see, for example, Domencich and McFadden, 1975). Although the method was developed for use in a study of electric vehicles (Beggs, et al., 1981; CRA, 1981), the model is readily adaptable to other situations, including motor-carrier service choice. The standard logit model is applied in situations where data are available on the most preferred of a number of alternatives. Shippers' actual choices among motor carrier, rail, and air models are examples of this situation. Ordered logit is applied when rank order data on preferences are available, i.e., in addition to the most preferred alternative, information on the second, third, etc., alternatives available.

In the ordered logit approach, the basic assumption is that preferences for products or services are explained by the attributes these products and services possess. Usually, these preferences, often labeled utilities, are represented as weighted sums of the attributes. The more important the attribute, the greater the weight. For example, if a particular type of shipper were willing to pay 10 percent higher rates to insure safe delivery, this could be inferred from the attribute weights. If the price premium were greater, the weight for the safety attribute would be correspondingly larger. The importance weights and the utilities for the alternatives are then used in a mathematical formula that produces market share estimates for existing and/or improved alternatives. This formula, which is identical to the multinomial logit formula, is:

$$MS_i = \exp(U_i) / \sum_j \exp(U_j) \quad \text{where}$$

$$U_j = a_1 X_{1j} + a_2 X_{2j} + \ldots \quad \text{where}$$

MS_i = the market share for the i^{th} alternative

U_i = the utility score for the i^{th} alternative

X_{kj} = the value on the k^{th} attribute for the j^{th} alternative and

a_k = the importance weight (coefficient) for the k^{th} attribute.

In many applications it is desirable to allow the importance weights to differ for different types of consumers. For example, shippers of bulk liquid products may have different sensitivities to price and safety than do shippers of dry bulk products. This approach allows the analyst to focus on particular market segments.

The importance weights are derived from experimental data in which people are asked to order several alternatives from first to last in order of their preferences, i.e., which alternative would they select first, second, and so on. The alternatives are defined by specific values on the attributes deemed to be important in selecting among alternatives. Some of the alternatives may closely resemble options currently available while others might be hypothetical, e.g., a low-cost, no-frills alternative may not currently exist in some markets.

The full rank order provides a large amount of data for each respondent. An ordered logit sample of a given size is roughly equivalent to $(J - 1)$ times a standard logit sample of the same size, where J is the number of alternatives. Therefore, previous studies have shown that reliable results can be obtained with samples of fewer than 100 respondents.

Since selection among alternatives can involve several attributes, a realistic representation of alternatives can be fairly complex. For example, in a study for a private client, CRA is using 16 alternatives defined in terms of 10 attributes in analyzing shippers' preferences for less than truckload (LTL) carriers. Therefore, ordinarily the data for ordered logit are collected in face-to-face interviews, and visual aids, such as cards, are used in assisting the respondent to order the alternatives.

CURRENT APPLICATION

Study Design

Application of the ordered logit model was part of a larger study, performed by the Harvard Business School, on the attitudes and preferences of shippers of bulk products following deregulation (Wyckoff, 1981 and 1982). A national

telephone survey, in which approximately 100 bulk shippers were interviewed, was conducted in October 1981. Respondents were customers of the National Tank Truck Carriers of the American Trucking Associations. Because of the limited time and monetary resources available for the study, the service attributes were limited to four: price, pickup and delivery dependability, financial stability of the carrier, and safety of the carrier.

Because of the restrictions imposed by telephone interviewing, the ordered logit data collection was quite simple in the number and levels of attributes and the number of alternatives. Consequently, this analysis should be viewed as a pilot study, designed to illustrate the capabilities of ordered logit; a study of particular market strategies would likely require a more elaborate design. Table 1 presents the attribute levels used in the survey. Four alternatives, defined in terms of specific values (levels) on the attributes were presented to the respondents, who ordered these alternatives according to their preferences.

Even though the choice exercise was very simple in comparison to previous applications involving face-to-face interviews with visual aids, there still was some difficulty for the respondents. Thirty-one respondents (32 percent) were unable to complete the exercise and another 17 produced rank orderings that appeared to include contradictory patterns, e.g., price was preferred to dependability in ranking the top alternative over the second, but dependability was preferred in ranking the third over the last. In contrast, a face-to-face interview was used for a much more difficult car choice study, CRA (1981a), in which it was found that only 6 percent of the respondents were unable to complete a rank order exercise involving 16 alternative cars defined in terms of 9 attributes. This contrast demonstrates the power of face-to-face interview with visual aids.

Results

The 50 respondents who produced "consistent" rank ordering were used in estimating the coefficients of the ordered logit models. (We also estimated the models using the additional 17 respondents who gave "inconsistent" rank orderings. The models were quite similar to those reported here, although not quite as sharply defined.)

Two versions were estimated. Because of the limitations imposed by telephone interviewing, the four alternatives presented to the respondents represent a rather simplified situation in which a lower price is always accompanied by lower dependability and in which investment in the safety program is accompanied by less financial stability. Because of this pattern of interdependency among the attributes, importance weights can be estimated only for the price and safety attributes when a single set of weights for the entire sample are desired.

In previous studies in which interdependency among attributes occurred, researchers have defined interaction terms, i.e., some of the interdependent attributes are multiplied by characteristics of the respondents in order to break up the interdependency patterns (see, for example, Lave and Train, 1979). This approach allows distinct importance weights to be estimated for each attribute. In addition, this approach results in the importance weights varying with respondents' characteristics, thus providing information on particular

TABLE 1

ATTRIBUTES INCLUDED IN ORDERED LOGIT ANALYSIS OF SHIPPERS' PREFERENCE

Attribute	Levels
Price	0 = 15 percent higher than standard rate 1 = standard rate
Dependability	0 = generally delivers within two days of schedule 1 = always delivers early or on time
Financial Condition	0 = questionable financial condition 1 = sound financial condition
Safety	0 = has an uncertain safety program 1 = has an unquestioned safety program

market segments. In this study, shipper type (1 = dry bulk, 2 = bulk liquids) was used to form interaction terms. Shippers of liquids include bulk liquid chemicals and petroleum shippers. Table 2 presents the two versions of the ordered logit model and Table 3 presents market share estimates from these models. The ordered logit models can be used to address the following questions:

- Is price more important than on-time performance; is safety more important than financial stability?
- What is the tradeoff between price and safety and other attributes?
- Are there variations in preference patterns for different types of shippers?

The following results can be inferred from the models.

- When the same set of weights was used for the entire sample (Model 1), price was clearly preferred to on-time performance and safety to financial stability. This is indicated by the positive and statistically significant coefficients for each variable and is further illustrated in Table 3, in which the sum of the market shares for the lower price carriers (1 and 3) is larger than that of the on-time carriers (2 and 4). Similarly, the sum of the market shares of the safe carriers (3 and 4) is larger than that for the financially solid carriers (1 and 2).
- When separate importance weights are used for shippers of liquids and dry bulk products (Model 2), distinct differences appear. The shippers of liquids strongly value lower price and safety, as illustrated by the market share predictions in Table 3. On the other hand, shippers of dry bulk products tend to value on-time performance and financial stability. This result clearly illustrates that careful market segmentation is essential in designing service strategies.
- The 15 percent price increment was valued approximately the same as the improved safety program. This outcome did not vary substantially for the entire sample or the separate subsamples. This result should be interpreted cautiously. This price change and the safety program are "package deals" in this particular example. That is, the price change is always accompanied by a depend-

TABLE 2

ORDERED LOGIT MODELS OF SHIPPERS' PREFERENCES

Variables	Model 1	Model 2
Price	.4463 (2.3572)	—
Price X Shipper Type[a]	—	1.1422 (2.7654)
Dependability	—	1.4242 (2.0061)
Financial Condition	—	1.6864 (2.4547)
Safety	.4888 (2.6405)	—
Safety X Shipper Type[a]	—	1.3213 (3.2991)
Number of Respondents	50	50
Likelihood Ratio Test[b]	13.00	31.45

Note: t statistics appear in parentheses below each coefficient.
Coefficients with $t > 1.96$ are significant at $p < .05$ and those with $t > 2.57$ are significant at $p < .01$.

a Shipper type is coded as follows: 1 = dry bulk products, 2 = bulk liquids.

b The likelihood ratio statistic is distributed chi square with degrees of freedom equal to the number of independent variables. Both statistics are signficant beyond $p < .01$.

TABLE 3

MARKET SHARE ESTIMATES FROM ORDERED LOGIT MODELS

(in percents)

	Model 1	Model 2	
	Entire Sample	Shippers of Bulk Liquids	Shippers of Dry Bulk Products
Carrier 1	23.2	19.5	25.4
Carrier 2	14.8	8.3	33.6
Carrier 3	37.8	50.8	17.6
Carrier 4	24.2	21.5	23.4

CARRIER DESCRIPTIONS

Carrier 1:

Charges the standard rate
Generally delivers within two days of schedule
Is of sound financial condition and
Has an uncertain safety program.

Carrier 2:

Charges 15 percent higher than the standard rate
Always delivers early or on time
Is of sound financial condition and
Has an uncertain safety program.

Carrier 3:

Charges the standard rate
Generally delivers within 2 days of schedule
Is of questionable financial condition and
Has an unquestioned safety program.

Carrier 4:

Charges 15 percent higher than the standard rate
Always delivers early or on time
Is of questionable financial condition
Has an unquestioned safety program.

ability change and the safety change is also always associated with a change in financial condition. In a more elaborate experimental design, these "packages" would be broken up, and the price/safety tradeoff could be different.

- The rather strong assumption used to estimate Model 2 permit conversion of each of the three nonmonetary attributes into monetary equivalents separately for each type of shipper.[1] Shippers of liquids would be willing to pay 9 percent higher rates to insure on-time delivery, 11 percent higher rates for a financially solid carrier, and 17 percent higher rates for an unquestioned safety program. For shippers of dry bulk products, the corresponding percentages are 19 percent, 22 percent and 17 percent, respectively. Although these tradeoff values seem to be consistent with what is actually happening in these segments of the motor-carrier industry, they should be viewed as illustrative of the type of information produced by the ordered logit model. A more elaborate experimental design, which is not constrained by the limitations of telephone interviewing, would produce more reliable values that are much less dependent on analytical assumptions.

CONCLUSIONS AND RECOMMENDATIONS

The pilot study of the applicability of the ordered logit model for analyzing

shippers' preferences for trucking services has produced some interesting and plausible results. This example has illustrated how the relative importance of service attributes can be estimated and how these weights may vary by market segments. The results appear to be clearer and more useful than those produced by more conventional market research methods. For example, paired comparison data collected in another part of the present study were not as interpretable or plausible as the ordered logit results (Wyckoff, 1982).

The full power of the approach for market research in the trucking industry awaits more elaborate study designs, such as the ongoing study by CRA mentioned earlier. This type of refinement has many potential benefits.

For example, in the standard face-to-face interview approach for ordered logit, respondents might be presented with several (more than four) alternatives defined in terms of one of three price levels, e.g., 15 percent discount, standard, 15 percent increase. Several other attributes would also be used. This type of design would permit the relative importance of the attributes to vary with the attribute values.

Further, a more elaborate design would provide more power in explaining attribute importances and in developing reliable market share estimates. A design that provides large variations in attribute values and alternatives clearly provides much more information than the limited application presented here. While this application has been useful in illustrating the ordered logit method, the relative importance of attributes and the usefulness of market segmentation, the full power of the methods is almost certainly tightly constrained in the telephone interviewing environment.

Beyond the particular findings on ordered logit and bulk shippers, this and other recent related studies suggest several broad principles for effective market research in the motor carrier industry.

First, it is important carefully to identify who is actually making the decisions to use particular carriers. Our studies indicate that there is considerable new influence being exerted by top management on carrier selections. The traffic manager is less likely to be the decisionmaker than in the past.

Second, it is important to define carefully the market segment that is being studied. Lumping together market segments may produce spurious results. For example, while shippers of bulk liquids were willing to pay a 9 percent premium for reliable pickup and delivery, we found that shippers of dry bulk products were willing to pay 19 percent.

Third, being imaginative in selecting new service features that have not been offered in the past may be important. The particular attributes used in this study are illustrative. Many others may be relevant in analyzing particular service strategies for various market segments.

Fourth, a neutral party should be used to collect the data so that the shippers' responses to questions are not directly or indirectly influenced by the viewpoints of the research (or top management).

After the research results have been obtained, the costs of providing the service feature would be compared with the premium (or discount) the shippers identified.

Finally, the product research will indicate what features need to be stressed in personal selling and advertising to target markets.

The number of shippers in the market segments must be large enough to be worth designing and producing a service for. Several segments that value product features in the same way might be combined to produce a profitable business.

In summary, the motor-carrier industry has a mature commodity product on its hands. If this situation persists, the industry will suffer the traditional price-cutting behavior of commodity industries in periods of excess capacity. The only time that margins will be recovered will be periods of sudden increases in demand that briefly outstrip capacity. This is not a very attractive state of affairs. The only hope is to find ways to differentiate the service product—other than prices. Using the traditional definitions of the motor-carrier product does little to help. Research dating from before the Motor Carrier Act of 1980 is so influenced by the regulatory setting that the data are suspect, therefore quite dangerous for strategic planning.

Just as the entire industry is struggling with rethinking the motor-carrier product, new market research techniques, such as ordered logit, for product design have emerged. Of course, each company will have to do its own homework and interpret its findings as a product offering. Some will be more creative and insightful than others. It will be difficult, because it will probably mean substantial changes in behavior and investment for some companies. Those carriers that elect not to undertake this challenge will face the cut-throat price competition of the commodity market.

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FOOTNOTES

1 For shippers of dry bulk products, the monetary equivalents are estimated by multiplying the coefficients of the nonmonetary attributes by 15 percent and then dividing by the price coefficient, using Model 2. For shippers of liquids the price and safety coefficient are doubled before performing the calculations.