Exhibit D

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Commercial Use of Conjoint Analysis: An Update

The authors report results of a survey conducted to update a previous one on the commercial use of conjoint analysis. They document an extensive number of applications and show systematic changes in their characteristics consistent with research results reported in the literature. Issues relevant to the options available to analysts involved in the conduct of conjoint analysis are identified and discussed.

A survey of conjoint analysis research suppliers was conducted to update a previous study (Cattin and Wittink 1982). A comparison of the results from the two surveys shows systematic changes in how studies are conducted. These changes tend to be consistent with the implications from conjoint research reported in the marketing literature. Many issues related to the conduct and implementation of a conjoint study warrant further examination.

Sampling of Commercial Users

As the method's popularity has grown and changes in data collection or analysis have been shown to be acceptable, the conjoint supplier population has grown as well. For the survey, we concentrated on these research suppliers to learn about commercial applications. We started with an American Marketing Association directory listing of 156 firms providing services on "all market research" techniques. We expected a relatively small number of the firms from this listing to be active in conjoint analysis and received 26 completed questionnaires for a return rate of 17%.[1] We identified 13 other research suppliers from advertisements in *Marketing News*. These firms either mentioned conjoint analysis as one of the services offered or the information suggested that conjoint analysis might be offered. From this group eight completed questionnaires were received, a response rate of 62%. We also used a listing of researchers who had requested information about a new conjoint software package introduced in 1985 to identify 57 additional firms.[2] From this group we received 15 completed

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[1]This response rate appears to be small. However, at the time the survey was conducted most of the firms included in the listing would not have offered conjoint analysis as a service. We believe that the 26 respondents represent at least 50% of the firms providing the service.

[2]Though the use of a list from one particular source may bias our survey results in the direction of features favored by that firm, such a bias should be slight or nonexistent for several reasons. First, our intent was to include firms that for whatever reason were excluded from the first two lists. Second, the listing included competitors of the firm that requested information to understand the competitive threat. Third, the software provided by the firm was not available for commercial use until the second half of 1985, the last year of the five-year period covered by our survey.

Journal of Marketing
Vol. 53 (July 1989), 91-96

questionnaires, a 26% return rate.[3] Finally, we used a list of 47 individuals who had attended a multivariate analysis seminar and were associated with other research suppliers. From this group 17 completed questionnaires were obtained, a 36% completion rate. On the basis of our prior knowledge of which firms definitely were providing conjoint services, we believe that the survey participants had responsibility for a large proportion of all commercial projects completed during the 1981–1985 period used for this survey.

The survey respondents together carried out 1062 projects during the five-year period in comparison with a total of 698 documented applications prior to 1981. Though we cannot be sure that our coverage of commercial applications is equal across the two surveys, the annual commercial use in the early 1980s appears to have exceeded the annual use during the 1970s. Part of this growth was due to additional suppliers entering the field. For example, approximately 30% of the respondent firms had started offering the service after 1980. To obtain independent judgments about the total number of commercial projects, we contacted several leading suppliers. Their estimates of the actual market varied greatly, ranging from 200 to 2000 a year. As we documented 1062 projects over a five-year period, the actual number is clearly greater than 200. The upper bound of the range of estimates may be more representative of usage in the late 1980s. For example, most of the software that facilitates the commercial use of conjoint first was introduced in 1985. As a consequence, the number of research suppliers offering conjoint analysis may have grown exponentially after 1985. In the early 1980s the annual commercial usage should have been closer to the lower bound. Our judgment is that this number may have been about 400 a year during the period of the survey.

Survey Results

Frequency of Usage by Product Category

We show in Table 1 that during 1981–1985 almost 60% of the applications were for consumer goods and less than 20% were for industrial goods. The largest change in relative frequency is for the service categories, which together account for 18% in 1981–1985 but 13% in the earlier survey. In general, however, the distributions of relative frequencies for the categories are very similar.

[3]The low response rate must be interpreted against the fact that these firms were not included in either of the first two lists. In many cases the firm was considering the opportunity to offer conjoint analysis as a new service, given the recent availability of conjoint software packages. Such a firm would have had no experience to report at the time the survey was conducted.

TABLE 1
Commercial Use of Conjoint Analysis

	Percentage of Applications[a]	
	1981–1985	**1971–1980**
Product/Service Category		
Consumer goods	59	61
Industrial goods	18	20
Financial services	9	8
Other services	9	5
Other	5	6
	100	100
Purpose[b]		
New product/concept identification	47	72
Competitive analysis	40	—[c]
Pricing	38	61
Market segmentation	33	48
Repositioning	33	—[c]
Advertising	18	39
Distribution	5	7
	100	
Means of Data Collection[c]		
Personal interview	64	
Computer-interactive method	12	
Mail questionnaire	9	NA
Telephone interview	8	
Combination	7	
	100	
Stimulus Construction		
Full profile (concept evaluation)	61	56
Paired comparisons	10	—[c]
Tradeoff matrices	6	27
Combination	10	14
Other	13	3
	100	100
Response Scale		
Rating scale	49	34
Rank order	36	45
Paired choice	9	11
Other[d]	6	10
	100	100
Estimation Procedure[e]		
Least squares	54	16
MONANOVA	11	24
Logit	11	10
LINMAP	6	—
Other[f]	18	55
	100	105

[a]The results reported are weighted by the number of projects completed by each supplier.
[b]A given study may involve multiple purposes.
[c]This category was not included in the 1989 survey.
[d]In the 1986 survey, this category was specifically defined as "constant sum."
[e]The percentages reported for 1971–1980 reflect the use of multiple procedures by some suppliers.
[f]This category includes PREFMAP and monotone regression for 1971–1980.

Project Purpose

One commercial project may serve multiple purposes. To determine the percentage of studies involving specified purposes, we identified seven different, but not mutually exclusive, categories. The results show that an average of slightly more than two identified purposes were served by a given study. Results from both surveys are reported in Table 1. The ordering of the categories common to both surveys according to frequency is identical across the two surveys. Interestingly, one of the new categories, competitive analysis, was the second most frequent purpose in the 1981–1985 time period. Competitive analysis is now a very common use of conjoint analysis, undoubtedly because of the opportunity to conduct market simulations.[4]

Means of Data Collection

We show in Table 1 that almost two thirds of the commercial applications were done by personal interview. The second most frequent means was computer-interactive procedures. The relative frequency during the 1981–1985 period for this means of data collection was only 12%. The use of mail questionnaires and telephone interviews was relatively infrequent. However, these means are particularly important if a probability sample is needed from a large geographic area. Mail surveys tend to have relatively low cooperation rates and the extent of cooperation will be lower still if the survey instrument requires additional explanations. (See also Cerro 1988 and Stahl 1988).

Stimulus Construction

During the 1981–1985 period, the full-profile procedure was used in almost two thirds of the commercial applications, a slight increase in relative use in comparison with the first survey. Tradeoff matrices account for only 6% of the applications[5] in contrast to 27% in the first survey. Thus, dramatic changes occurred in the relative popularity of alternative data collection methods, as documented in Table 1. Several reasons can be suggested for the decline in popularity of tradeoff matrices. First, respondents participating in a conjoint survey object to the tradeoff matrix format (e.g., Currim, Weinberg, and Wittink 1981, p. 70). Second, the matrix format is more artificial than the full-profile method. Third, the analysis of rank-order preferences is complicated when the matrices differ, as they usually do, in dimensionality. This complication requires users to have access to and knowledge about special algorithms.

A preference rank order of the cells in a tradeoff matrix can be obtained indirectly, however, by using paired comparisons. One also can construct object pairs from a full-profile design, using more than two attributes at a time. In general, paired comparisons account for 10% of the commercial applications.

[4]In more than half of the applications, market or preference shares were predicted.

[5]According to Johnson (1987, p. 257), the tradeoff matrices method ". . . has become nearly obsolete."

Response Scale

Traditionally, conjoint data are collected on a nonmetric scale. Ranked input data also are expected to be more reliable (Green and Srinivasan 1978). Interestingly, however, the relative popularity of rank-order response scales was lower during 1981–1985 than in the 1971–1980 period. Rating scales now account for almost half of the commercial applications in comparison with slightly more than a third in the first survey. Several reasons may account for this change. One is that with rank-order data, the maximum difference in parameter estimates for the best and worst levels of an attribute depends on the number of intermediate levels. Both part-worth values and inferred importances may not be comparable across attributes with varying numbers of attribute levels (Wittink, Krishnamurthi, and Nutter 1982).

Estimation Method

During 1981–1985, least squares was used five times as often as MONANOVA, whereas MONANOVA was the more frequently used method during 1971–1980. This change is consistent with empirical and simulation findings about the relative performance of alternative estimation methods on rank-order data (Carmone, Green, and Jain 1978; Jain et al. 1979; Wittink and Cattin 1981). In addition, the increasing use of rating scales (see Table 1) strengthens the case for least squares. Still, a preference for nonmetric procedures is sometimes expressed (Johnson 1987), even though such procedures applied to ratings are likely to have lower predictive validity than metric procedures (e.g., Huber 1975).

Some estimation procedures can accommodate a variety of preference model specifications. The main-effects part-worth model is the most popular specification, yet for a continuous attribute (such as price[6]) a continuous function can often provide more efficient estimates. Researchers who care about the model specification validity and estimation efficiency will gather sufficient data to test models, at least at an aggregate level. Interestingly, such tests often favor a model with interaction effects. For example, Louviere (1988) has obtained considerable evidence that respondents treat attributes complementarily. For designs that accommodate specific interactions, see

[6]Price was included as a separate attribute in almost two thirds of the commercial applications. For the estimated price sensitivity to be meaningful, price must be carefully labeled as the cost of the product. Also, study participants must understand that objects differ only in the characteristics explicitly listed and that a higher or lower price has no implications for characteristics not included in the study.

Carmone and Green (1981). Importantly, model comparison tests should reflect a study's purpose (Hagerty 1986).

Reliability

The reliability of conjoint results is partly a function of the number of respondents (e.g., for market simulations). The typical sample size reported by survey respondents has a median of 300. To determine the required sample size, analysts may use standard statistical inference formulas. However, these formulas assume probability sampling of respondents.

For the number of preference (tradeoff) judgments per respondent, we obtained a median value of 16 for the typical application. The reliability is also determined by the number of attributes used (a median of eight attributes) and the number of attribute levels (a median of three levels for the typical study). On the basis of this information, the reliability of results at the level of an individual respondent appears typically to be very low. Indeed, 16 judgments seems inadequate for the estimation of all parameters in a study using eight attributes and three levels per attribute in a part-worth model. Perhaps other information is combined with the preference judgments (e.g. Green 1984; Green, Goldberg, and Montemayor 1981). Still, these numbers underscore the importance of substituting continuous functions whenever possible.

More research is needed to assess systematic differences in results due to alternative data collection procedures. Reibstein, Bateson, and Boulding (1988) examined the reliability of individual-level parameter estimates for alternative stimuli and attribute configurations as well as data collection methods. Overall, their results suggest a respectable degree of reliability. However, conclusions about differences in reliability between alternative manipulations and data collection procedures may depend on the reliability measure adopted (Wittink et al. 1988).

Validity

The closest conjoint studies usually come to validation is by comparing predicted market shares from a simulation for the objects available in the marketplace with their actual market shares (e.g. Clarke 1987, p. 185). However, for this validation attempt to be meaningful, adjustments should be made for the extent to which respondents are aware of and have access to each of the brands. Such adjustments have been an important feature of simulated test-market model predictions (e.g., Silk and Urban 1978). Another key component of market share predictions is the choice rule assumed to apply to the respondents. Commonly a respondent is assumed to choose the object with the highest predicted preference (first-choice rule). However, more needs to be known about the (relative) performance of alternative choice rules[7] (see, e.g., Finkbeiner 1988).

One of the most appealing characteristics of conjoint analysis is the option to simulate a variety of market scenarios and to make market (preference) share predictions. However, for projectability of these predictions to a target market, a probability sample is necessary. This condition is rarely satisfied. Instead, respondents tend to be selected purposively on the basis of demographic or socioeconomic characteristics. The validity of market simulation predictions depends also on the completeness of the set of attributes used to define objects, yet an analyst may focus on a reduced number of attributes to simplify the task for respondents. The increasing interest in and use of market simulators makes it important to use an extensive set of attributes, which places a premium on designs that can accommodate many attributes (e.g., by allowing the set of attributes and their levels to be respondent-specific). Analysts also can utilize computer programs that identify the characteristics of an "optimal" product for market share or profit maximization (e.g., Green, Carroll, and Goldberg 1981). Optimization algorithms are available for product lines as well (Green and Krieger 1985).

Postsurvey Developments

Toward the end of the survey period, conjoint software packages were introduced. As a result, the cost of conjoint applications has declined because the software can be thought of as a substitute for expert knowledge. We therefore expect an acceleration in the growth of conjoint applications. Some of the software is designed specifically for computer-interactive data collection. This approach may be favored for several reasons. First, respondent interest in and involvement with the computer-interactive tasks seem to be high (Johnson 1987, p. 263). Second, the flexibility of computer-interactive approaches affords substantial advantages. By using different attributes and levels for different respondents, one can include a larger number of attributes and levels in a study without overwhelming the respondents. Third, it is easy to include options for determining a respondent's consistency in providing preference judgments. Fourth, parameters can be estimated as soon as a sufficient number of judgments is obtained. The number and kind of additional preference judgments needed from a respondent can be made to depend on the change in the es-

[7]One difficulty is that the predicted values for objects are usually measured on at best an interval scale. Thus, admissible transformations can have dramatic effects on predicted market shares (with the exception of the first-choice rule). To get around this problem, preferences can be measured as probabilities of choice.

timated precision of parameter estimates. Fifth, at the end of the exercise, results can be shown to the respondent. Also, as soon as the results are obtained from all respondents, market-level predictions can be made. Thus, the results can be communicated to managers much more rapidly, which is particularly important when conjoint is used at some stage in a time-constrained new product development process.

One of the attractive features of conjoint analysis is that it provides information about the influence ("importance") of attributes on the preference for objects. However, increasingly conjoint procedures are adapted to include direct attribute assessments. For example, in adaptive conjoint analysis (Johnson 1987), the parameter estimates are obtained by combining direct assessments of attribute levels and paired-comparison evaluations. However, the influence (weight) of the direct assessments on the parameter estimates is allowed to decrease as the number of paired-comparison judgments provided by a respondent increases.

Green has popularized the use of hybrid methods (e.g. Green 1984). In these procedures direct attribute assessments are combined with information from preference judgments about objects. The increasing interest in using direct assessments is also evident in Srinivasan's (1987) model of choice as a two-stage process. In his procedure, respondents are given the opportunity to eliminate unacceptable attribute levels. Subsequently, a compensatory model is applied to explain preferences for objects with acceptable levels. For this model, self-explicated weights are based on attribute importances and attribute-level desirabilities. Similar to the derived attribute importances inferred from conjoint results, the stated importances are defined in terms of the differences between the best and worst of the acceptable attribute levels. In an empirical application, Srinivasan obtained slightly higher predictive validity of 1982 MBA job choice data than was obtained by Wittink and Montgomery (1979) with tradeoff-matrix data on 1979 job choices.

We note that the elicitation of unacceptable attribute levels is a form of direct assessment, even if this information is used primarily to simplify the data collection task. Johnson (1987, p. 259) argues that the elimination of unacceptable levels should be included only when "the interview is otherwise too long." This word of caution appears to be consistent with the results of a recent study designed to investigate the validity of unacceptable level assessments (Green, Krieger, and Bansal 1988).

Conclusions

From a survey of research suppliers, we have documented 200 conjoint applications a year, during 1981–1985, though we believe the actual average may be about twice that number. In addition, since 1985 use may have become more widespread because of the introduction of conjoint software. The availability of programs that provide customized study designs and analyses also has reduced the cost per study substantially.

We highlight differences between this survey and comparable results for the 1971–1980 period. The comparisons show a systematic reduction in the use of rank-order preferences relative to judgments obtained on a rating scale. In addition, data analysis is based on regression analysis in the majority of applications. The reported changes are directionally consistent with the results from studies reported in the literature.

During the period of the first survey, academic researchers placed great emphasis on the relative merits of alternative data collection and analysis methods. In the 1980s attention shifted to more refined data collection procedures, optimal combination of directly stated attribute evaluations and object preferences, flexibility in the preference tasks and the ability to accommodate many attributes, market simulation procedures, and choice rules. Additional research would be helpful to determine the extent to which rating scales provide interval-scaled preference judgments. Also, alternative functional forms, including allowances for attribute interactions, should be compared. Though conjoint analysis appears to be widely used and accepted, there is little documented evidence on the validity of market predictions made. More research is needed also on the applicability of alternative approaches, including software packages, for different product categories and types of applications.

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Reprint No. JM533107