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CONJOINT MEASUREMENT: A MARKETING LITERATURE REVIEW WITH AN ANNOTATED BIBLIOGRAPHY

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Introduction

Conjoint measurement is a fundamentally different, relatively new means of measurement developed by Tukey and Luce in 1964. In the nine or so years since their break-through only a limited literature has evolved, mainly in mathematical psychology and psychometrics. The marketing literature dealing with conjoint measurement is even more scanty, consisting of only two Journal of Marketing Research articles and a handful of working papers and presentations of limited circulation. (However, Green and Rao do have a book forthcoming.)

This limitation is not as severe as might be supposed, however, because Young has shown that the nonmetric, multidimensional scaling models represent a special case of the more general conjoint measurement model.[1/] The literature is replete with discussions of these models even though their history goes back only another two years to Shepard in 1962.

Conjoint Measurement

What is it?

The literature which does exist provides these explanations for conjoint measurement:

> The word "conjoint" has to do with the fact that we can measure relative values of things considered jointly which might not be measurable taken one at a time.[2/]

1/ Forest W. Young, "A Model for Polynomial Conjoint Analysis Algorithms," in Multidimensional Scaling, Vol. I, ed. by Roger N. Shepard, A. Kimball Romney, and Sara Beth Nerlove (New York: Seminar Press, 1972), p. 70.

2/ Richard M. Johnson, Trade-off Analysis: A Method for Quantifying Consumer Values (Chicago: Market Facts, Inc., September, 1972), p. 2.

An outcome or an event is conjoint if it represents a combination of two or more elements. Response to relationships involving pairs of objects is conjoint as is also the case of a response to a pair of items involving a person and an object. If we can establish an order relation on such pairs, we may be able to upgrade the data to some stronger form of scale [Italics in the original].3/

This approach holds some promise for describing aspects of personal choice among complex alternatives where no alternative "dominates" the others (i.e., is at least as good as any other on all attributes of interest and is strictly better than any other on at least one).4/

Conjoint measurement is concerned with the joint effect of two or more independent variables on the ordering of a dependent variable [Italics in the original].5/

In the conjoint measurement series we are concerned with deriving a set of values from a specified polynomial of lowest degree, such that the values map into a set of ranks.6/

...new measurement models by which one's preferences over a set of multi-attribute alternatives can be structured in terms of the part-worth contribution that each attribute state makes to one's overall evaluation of a multi-attribute alternative. This approach [is] called conjoint measurement.7/

3/ Paul E. Green and Frank J. Carmone, Multidimensional Scaling and Related Techniques in Marketing Analysis (Boston: Allyn and Bacon, 1970), p. 10.

4/ Paul E. Green, "Multi-Attribute Decisions in Marketing Behavior," The Wharton Quarterly, Vol. VII (Fall 1972), p. 47.

5/ Paul E. Green and Vithala Rao, "Conjoint Measurement for Quantifying Judgemental Data," Journal of Marketing Research, Vol. VIII (August 1971), p. 355.

6/ James C. Lingoes, "A General Survey of the Guttman-Lingoes Nonmetric Program Series," in Multidimensional Scaling, Vol. I, ed. by Roger Shepard, A. Kimball Romney, and Sara Beth Nerlove (New York: Seminar Press, 1972), p. 63.

7/ Green, "Multi-Attribute Decisions."

Green notes further that conjoint measurement represents a new type of measurement because behavioral scientists cannot usually obtain data more strongly scaled than rank order, yet the results of conjoint measurement are intervally scaled.[8/] And Johnson has used conjoint measurement to produce ratio-scaled values.

Young has outlined the general nature of conjoint measurement as follows:

> it is often the case that while one of the goals of scientific investigation is the decomposition of complex phenomena into basic factors, the factors cannot be measured independently and that only the order of their joint effects is known. This is the conjoint measurement problem and the combination rule is known as the conjoint measurement model.[9/]

To further help conceptualize the nature of conjoint measurement, note that Taylor (in a conversation with the author) suggested that the method can be thought of as the analysis of variance for ranked data. This is, in fact, how Young described Tukey and Luce's original work: "it is basically an additive model and...an analog of two way analysis of variance."[10/]

Research into the character of conjoint measurement has proceeded in two directions: one has been a continued investigation into its theoretical bases, and the other has been the development of computer algorithms for constructing the actual scales themselves.[11/] While Green's work has

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8/ Ibid., p. 48.

9/ Young, "A Model," p. 69.

10/ Green, "Multi-Attribute Decisions," p. 48.

11/ Young, "A Model," p. 77.

focussed on an additive version of the model, Young and others have shown that a great many other model formulations are possible (multiplicative, lexicographic, interactive, etc.). Several versions of the additive and multiplicative models are well known and available. Further, though additive models are more frequently encountered in practice, according to Johnson the difference between them and a multiplicative model is important only in a computational sense.12/ For example, by the use of logs a multiplicative model could be converted to an additive one.

Researchers at Market Facts, Incorporated, a private market research firm, have tied conjoint measurement to classical economic utility theory. Fiedler, for example, has suggested that, "It is possible that the consumer is unaware of the numerical values of his utilities, but that they may be revealed through his choices among product concepts."13/ Moreover, Johnson has added, "The basic idea is that by providing consumers with stimuli from among which to chose, we can make inferences about their value systems based upon behavior rather than self-reports."14/

Johnson has also argued that conjoint measurement provides data superior to that obtained from asking consumers for judgements regarding the

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12/ Johnson, Trade-off Analysis, p. 4.

13/ John A. Fiedler, Condominium Design and Pricing: A Case Study in Consumer Trade-off Analysis (Chicago: Market Facts, Inc., at the Association for Consumer Research, November 3, 1972), p. 1.

14/ Johnson, Trade-off Analysis, p. 2.

importance of various attributes, because these judgments are not necessarily meaningful unless obtained in a specific context.[15/] Thus the importance of the attribute, safety, might vary as it refers to children's pajamas or to automobiles. Further, a conjoint measurement procedure is seen as superior to the task of having the consumer identify ideal levels of attributes because in many cases this ideal will vary from consumer to consumer, and in other cases all consumers will want as high or as low a level for an attribute as is possible, i.e., safety or price.[16/]

In conclusion, "conjoint measurement is considered a practical application of the economists' utility theory of buyer behavior in that... choice behavior is governed by a trade-off between... values such that though the utilities may not be able to be articulated, they will be revealed by choice behavior."[17/]

How does it work?

Operationally, the essence of conjoint measurement can be simply described. The first step is to obtain rank-order data on all critical combinations of attributes. In theory there can be any number of attributes, and each attribute can be multi-leveled, i.e., several prices or colors, etc. This

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15/ *Ibid.*, p. 1.

16/ *Ibid.*

17/ *Ibid.*, p. 2.

arrangement can be conceived as a matrix, with each cell containing a number which indicates the rank (relative desirability) of that combination of attributes. (The existing algorithms can handle ties and missing data.)

The next step requires the use of one of the computer algorithms to generate a model whose coefficients are such that when they are combined (added, multiplied, etc.) they will produce a matrix whose numerical values in each cell rank in the same order as the original data.

TABLE 1

Rank Order by Weight

Size	Platinum	Gold	Silver	Steel	Aluminum
Largest	1	2	5	8	15
Large	3	4	9	11	20
Medium	6	7	13	14	22
Small	10	12	17	19	24
Smallest	16	18	21	23	25

Source: Richard M. Johnson, Multiplicative Conjoint Measurement: A Physical Example (Chicago, Ill.: Market Facts, Inc., October, 1972), p. 1.

Table 1 corresponds to the first step: A respondent ranked twenty-five metal balls in terms of their weight.

TABLE 2

A Conjoint Measurement Solution

Row Factors	Column Factors .4121	.2999	.1499	.1091	.0290
.4717	.1943 (1)	.1415 (2)	.0707 (5)	.0515 (8)	.0137 (15)
.2376	.0979 (3)	.0712 (4)	.0356 (9)	.0259 (11)	.0069 (20)
.1716	.0707 (6)	.0515 (7)	.0257 (13)	.0187 (14)	.0050 (22)
.0858	.0354 (10)	.0257 (12)	.0129 (17)	.0094 (19)	.0025 (24)
.0332	.0137 (16)	.0100 (18)	.0050 (21)	.0036 (23)	.0009 (25)

Source: Richard M. Johnson, Multiplicative Conjoint Measurement: A Physical Example (Chicago, Ill.: Market Facts, Inc., October, 1972), p. 2.

Table 2 corresponds to the second step: A model was created so that when its coefficients (the row factors and column factors) were multiplied together the numbers yielded were ranked in the same order as in the original matrix.

Johnson pointed out that the row and column factors in Table 2 can be modified in two ways without destroying their ordering property. For example, each set of row factors or column factors could be multiplied by a constant or raised to the same power, and the ranking order would be preserved.[18/] Thus, by rescaling these row and column factors, we can approximate not only the original rank orders of the metal balls but also their actual weights when these were unknown to begin with!

18/ Richard M. Johnson, Multiplicative Conjoint Measurement: A Physical Example (Chicago: Market Facts, Inc., October, 1972), pp. 2-3.

The conjoint measurement programs are iterative in nature and usually cease calculating when one of three conditions is met:[19/]

1. when a goodness or badness of fit criterion is at an acceptable level;

2. when there is no significant improvement in fit after a specified number of iterations;

3. or when a specified number of iterations has been reached.

There are several criteria used to establish goodness (or badness) of fit. The most commonly used is Kendall's Tau, but another has been developed and called Theta by Market Facts. Still another developed by Market Facts has been termed Phi.[20/] Tau is based on a count of errors between actual ranks and computed ranks without regard for their size; Theta is obtained by cumulating squared differences (and seems similar to Kruskal's Stress); and Phi is based on ratios.[21/] Johnson reported that, although the three measures are theoretically different and have separate mathematical properties and weaknesses, i.e., degeneracy, in practice all three have worked equally well.[22/] Young, in his paper on conjoint

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19/ J.D. Davidson, Forecasting Demand for a New Mode of Transportation (Chicago: Air Canada, Association for Consumer Research, November 3, 1972), p. 4.

20/ Johnson, Trade-off Analysis, pp. 10-11.

21/ Ibid.

22/ Ibid.

measurement, discusses his versions of these fit criteria in somewhat different terms.[23/]

So far there have been two ways to collect data usable for conjoint measurement. One method has been that chosen by Green and Rao, and the other has been developed by Market Facts, Inc.

The Green-Rao method can be considered more realistic conceptually, but operationally it is more difficult to use.

> Their approach consists of providing respondents with product concept descriptions with each concept having a defined level of each attribute. The respondent's task is to provide rank orders of preference among a set of such concepts.[24/]

Because each concept is elaborately defined, realism is presumed to adhere, but "for many product categories it appears that upwards of a dozen product attributes may have to be studied simultaneously," and "it is hard to see how this many attributes can be handled if all concepts are to be given a specified level of each attribute."[25/]

The point here is that very quickly we can see that a respondent could be called on to make an awesome number of comparisons, many of which would be of an extremely difficult nature. This procedure is clearly unfeasible as is the design of such a questionnaire. Therefore, Green, Wind, and Jain,

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23/ Young, "A Model," pp. 80-84.

24/ Johnson, Trade-off Analysis, p. 13.

25/ Ibid., p. 25.

in one experiment, used only thirty out of a possible sixty combinations in a menu-ranking task.[26/] And Green used a Latin Square design with what he perceived as the chief combinations of attributes in a hypothetical example involving the design of a floor-wax package.[27/]

The Market Facts data-collection procedure "has respondents rank order several subsets, with the concepts in each subset varying in only two attributes."[28/] Here again there can be only so many ranking tasks before respondents fatigue, but at least each ranking task is feasible. The procedure Market Facts has used most often consists of a personal interview in which the respondent is given a booklet, each page of which contains a trade-off matrix "with rows representing various levels of one attribute and columns representing levels of a second attribute."[29/] The respondent is asked to rank the cells in this matrix, considering all other attributes to be held at a constant. It is at this point that the Market Facts procedure differs critically from Green and Rao's. The "other things being equal" instruction makes the whole procedure less realistic.

26/ Paul E. Green, Yoram Wind, and Arun K. Jain, "Preference Measurement of Item Collections," Journal of Marketing Research, Vol. IX (November 1972), p. 373.

27/ Green, "Multi-Attribute Decisions," pp. 48-9.

28/ Johnson, Trade-off Analysis, p. 13.

29/ Ibid., p. 12.

Market Facts has derived from its experience several rules of thumb which are worth noting:

1. Three appears to be the optimal number of levels for an attribute. In no case should a trade-off matrix have more than sixteen cells and nine is greatly to be preferred. This is a psychological limitation as respondents are overwhelmed by large matrices.

2. Each attribute should be compared to at least two and preferably three other attributes.

3. A respondent should have no more than about twenty ranking tasks.

4. Each pair of attributes which are not compared directly should be connected by a chain of comparisons no longer than about three links.

5. About sixteen attributes is the largest number that can be handled without compromising the above conditions. A smaller number is preferable.[30/]

Additionally, Johnson noted that the role of the interviewer is important, for he must ensure that the respondent does not begin to reply mechanistically to the ranking task.[31/]

What are its advantages and limitations?

There are two very obvious and practical advantages to conjoint measurement. First, from the relatively weak data input of ranks, results

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30/ *Ibid.*

31/ *Ibid.*

scaled at the interval or ratio level are possible. Since much behavioral science data are really only rank ordered, despite working assumptions to the contrary, this procedure is quite desirable. Second, conjoint measurement has a very wide area of applicability. A third and more theoretical advantage inherent in conjoint measurement is that

> a large number of different models in diverse areas of behavioral science already conform to the notions of polynomial conjoint measurement.
>
> Savage's expected-utility model in economics, the Hullian and Spencian performance models in psychology and the scaling models in psychometrics are but a few examples.32/

Young goes even further in speculating about the usefulness of conjoint measurement:

> If in fact the analytic method proposed here is an useful as it appears to be, and if specific polynomial conjoint measurement models are found to describe data from many areas of research in the behavioral sciences, then the structure of polynomial conjoint measurement theory becomes more than simply a theory of measurement. It becomes a general unifying theory of behavior.33/

This statement may sound extreme, but nonetheless it is interesting to contemplate such a possibility.

There are also, of course, several limitations to the use of conjoint measurement. One set of weaknesses stems from the assumptions of the

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32/ Young, "A Model," pp. 101-102.

33/ Ibid.

model. The model assumes that the attributes studied are independent. Johnson explained that this assumption of independence has two ramifications. "The first is that the attributes must be non-redundant or more accurately equally redundant."34/ Here the problem is to prevent overlap or attribute substitutions when we present a list of attributes to a respondent. However, "lacking a good way to measure the extent of redundancy among the attributes in a list," it seems the best that can be done is "to attempt to formulate attribute lists which are as non-redundant as possible."35/

The second ramification of the independent assumption is that interaction among the variables must be at or near zero. For example, the degree to which a respondent prefers a dessert is independent of what he has had for a main course. Clearly this assumption of no interaction will be false in some cases, but "it appears to be nearly enough true to be workable under ordinary circumstances."36/

Green and Rao suggested additional limitations. One is the previously discussed problem of getting around ranking tasks of too formidable a nature. They commented that presently "little is known about which (and how many)

34/ Johnson, Trade-off Analysis, p. 13.

35/ Ibid., p. 14.

36/ Ibid.

comparisons are the best ones to omit."[37/] Finally, in the interests of elegance, they speculated that it may be possible to obtain equally comparable results by asking respondents to provide numerical data directly rather than first obtaining ranks and using conjoint measurement procedures to generate numerical values for the utility analysis.[38/] No tests of this hypothesis have been made to date.

What are some applications?

Although the number of articles in the literature is few, nonetheless many applications of conjoint measurement in marketing have been tried or suggested. Market Facts has used its multiplicative model of conjoint measurement in pricing condominium apartment units in a building, and it feels the model can be of use in planning future building configurations.[39/] In addition, Market Facts has used its version to study inter-city air travel for Air Canada, "the market for sophisticated office equipment, the operation of urban mass transit systems...[and] financial services and government regulation."[40/]

37/ Green and Rao, "Conjoint Measurement," pp. 359-360.

38/ Ibid.

39/ Fiedler, Condominium Design and Pricing, p. 18.

40/ Ibid.

Green and Rao, as well as Green, Wind, and Jain, have also suggested several applications for conjoint measurement. Some of these applications have been selecting medical journals for ethical drug advertising; evaluating discount cards to be offered to housewives; evaluating the seriousness of various kinds of drug abuse; evaluating vendors; determining price-value combinations; appraising new ventures; measuring attitudes; measuring the joint aspects of a promotional campaign;[41/] and determining the utility of item collections.[42/]

Other suggested applications include evaluating package-design components; determining market segments on the basis of product benefits; deciding what type of label information to use; measuring the contribution of testimonial advertising to commercial effectiveness, recall, believability, etc.; estimating management utility functions; and examining differences among interest groups regarding public-service activities.[43/]

Conclusion

In summation, conjoint measurement models hold much promise for both the marketing practitioner and the theorist. The practitioner can utilize the models to make better marketing decisions in situations where critical

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41/ Green and Rao, "Conjoint Measurement," pp. 356-363.

42/ Green, Wind, and Jain, "Preference Measurement."

43/ Green, "Multi-Attribute Decisions," p. 51.

variables have joint effects on an outcome. And the theorist will find conjoint measurement helpful in building models of buyer cognitive and emotional processes.

Placing Conjoint Measurement in the Taylor-Kinnear Multivariate Method Class System

Taylor and Kinnear have recently published a working paper in which they updated their classificatory scheme for multivariate methods.[44/] (See Journal of Marketing, Vol. 35, No. 4 [October, 1971], for their original scheme.) One of the modifications they included was the addition of conjoint measurement to the group of nonmetric interdependence methods.

If, however, as Young argues, conjoint measurement is the general model for nonmetric multidimensional scaling, then the Taylor-Kinnear chart could be slightly modified as shown in Figure 1.

44/ James R. Taylor and Thomas C. Kinnear, "Multivariate Methods in Marketing Research," Working Paper No. 72 (Ann Arbor: Graduate School of Business Administration, The University of Michigan, 1973).

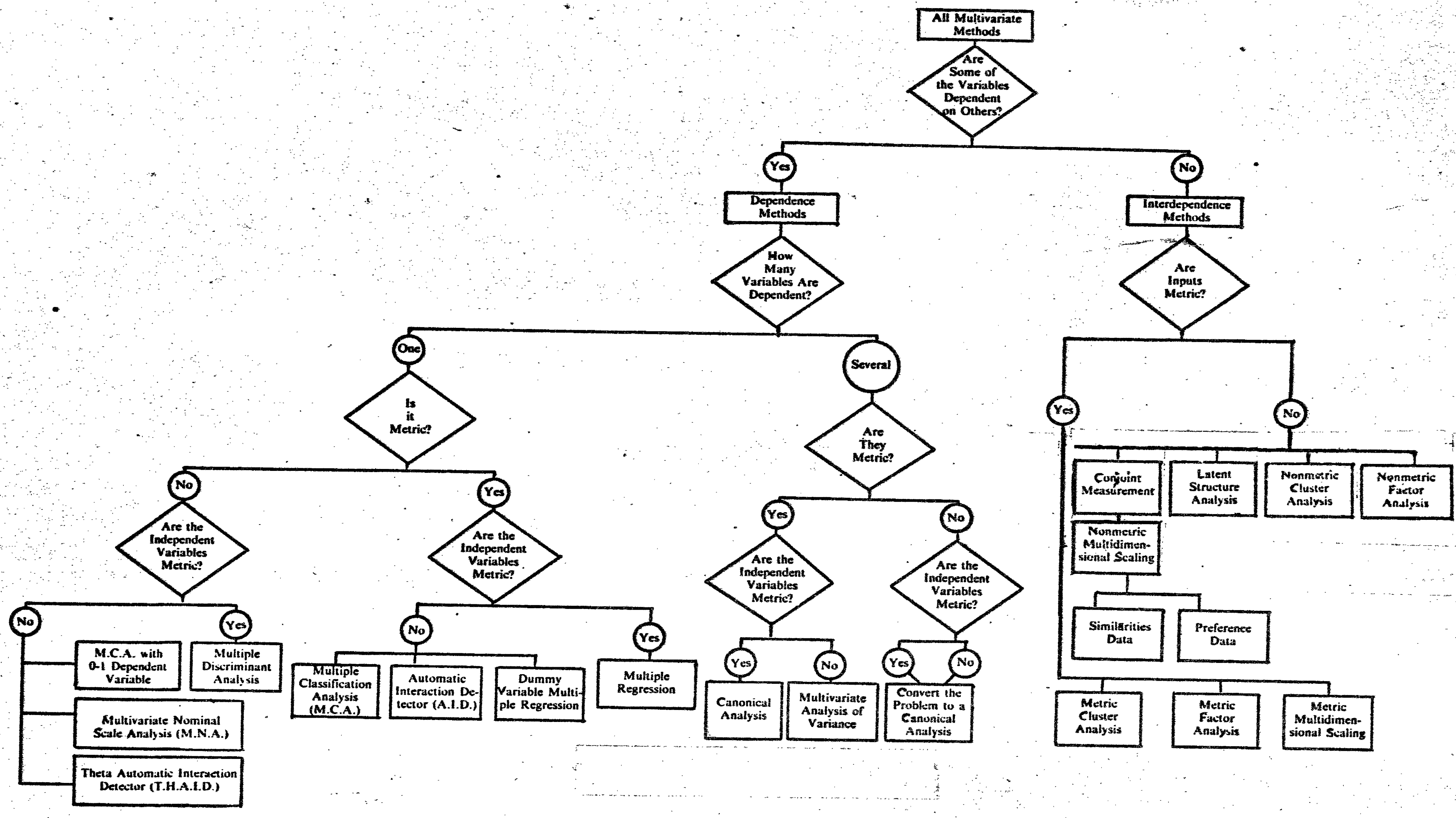

Fig. 1 A Classification of Multivariate Methods. (Source: Adapted from James R. Taylor and Thomas C. Kinnear, "Multivariate Methods in Marketing Research," Working Paper No. 72 [Ann Arbor: Graduate School of Business Administration, The University of Michigan, 1973], p. 14.)

Annotated Bibliography

Davidson, J.D. Forecasting Demand for a New Mode of Transportation. Chicago: Air Canada, Association for Consumer Research, November 3, 1972.

This paper can be divided into two parts. The first part utilizes the Market Facts conjoint measurement model to estimate the importance of various attributes involved in inter-city travel between Montreal and Ottawa. The second half of the paper then uses the data so generated to build a forecasting model for air usage of STOL aircraft.

Fiedler, John A. Condominium Design and Pricing: A Case Study in Consumer Trade-off Analysis. Chicago: Market Facts, Inc., Association for Consumer Research, November 3, 1972.

In this presentation is a very clear discussion of the background and solution to the problems faced by a building developer in New Jersey. A multiplicative conjoint measurement model was used to aid in the pricing of condominium apartments, some of which viewed the Manhattan skyline and others of which did not.

Green, Paul E. Mimeographed rough notes handed out at the American Marketing Association Doctoral Consortium at Austin, Texas, 1972.

Green, Paul E. "Multi-Attribute Decisions in Marketing Behavior." The Wharton Quarterly, Vol. VII (Fall, 1972), pp. 47-51.

This very brief article is really a recapitulation of what Green has written elsewhere concerning conjoint measurement. In it, however, he does present some additional potential applications.

Green, Paul E., and Carmone, Frank J. Multidimensional Scaling and Related Techniques in Marketing Analysis. Boston: Allyn and Bacon, 1970.

One of the Marketing Science Institute Series, this book, though relatively short, introduces the basic methods and problems of multidimensional scaling. It includes a twenty-page appendix on available computer programs and a thirty-six page bibliography.

Green, Paul E., and Rao, Vithala. "Conjoint Measurement for Quantifying Judgemental Data." Journal of Marketing Research, Vol. VIII (August, 1971), pp. 355-63.

This was the first article on conjoint measurement to appear in the marketing literature. Necessarily brief because of the journal's format, Green and Rao skipped the background and explanation of conjoint measurement to focus on how it might be applied. They favor an additive model.

Green, Paul E.; Wind, Yoram; and Jain, Arun K. "Preference Measures of Item Collections." Journal of Marketing Research, Vol. IX (November, 1972), pp. 371-77.

Here Green et al. extend the work of his first JMR article to the consideration of a collection of items so that taken together they could be viewed as a single attribute. Additional applications are also suggested.

Johnson, Richard M. Multiplicative Conjoint Measurement: A Physical Example. Chicago: Market Facts, Inc., October, 1972.

In ten pages, by means of an ingenious physical example from physics, Johnson explains the basics of conjoint measurement.

Johnson, Richard M. Trade-off Analysis: A Method for Quantifying Consumer Values. Chicago: Market Facts, Inc., September, 1972.

Written for the nonmathematician, this working paper, in superlative fashion, introduces the technique of conjoint measurement. It is highly recommended.

Lingoes, James C. "A General Survey of the Guttman-Lingoes Nonmetric Program Series." Multidimensional Scaling, Vol. I. Edited by Roger N. Shepard, A. Kimball Romney, and Sara Beth Nerlove. New York: Seminar Press, 1972, pp. 49-68.

As you would expect from the title, in this selection Lingoes discusses in general terms the features of the several nonmetric multidimensional scaling algorithms which he and Guttman have written. Three conjoint measurement algorithms are mentioned.

Taylor, James R., and Kinnear, Thomas C. "Multivariate Methods in Marketing Research." Working Paper No. 72, Graduate School of Business Administration, The University of Michigan, 1973.

In this short presentation, the reader is introduced to several of the very new multivariate research tools (MNA, THAID, and conjoint measurement). There is also a highly useful updating of their classification scheme for multivariate methods.

Young, Forest, W. "A Model for Polynomial Conjoint Analysis Algorithms." Multidimensional Scaling, Vol. I. Edited by Roger N. Shepard, A. Kimball Romney, and Sara Beth Nerlove. New York: Seminar Press, 1972, pp. 69-104.

For the psychometrician, Young's selection seeks to consolidate many of the existing conjoint measurement models and nonmetric multidimensional scaling models into one general theory. He discusses at some length the mathematical and statistical underpinnings of the theory of conjoint measurement and its tests of goodness of fit.