Applications of Structural Equation Modeling in Consumer Choice Studies

[1]Prithvish Bose
[1]Associate Professor,
[1]Amity Business School,
[1]Amity University Chhattisgarh, Raipur, India

Abstract:

Structural Equation Modelling (SEM) is a unique tool in the hand of researchers who can use it for both theory testing and theory building. It has thus gained popularity as the preferred method in many studies, especially in studies related to consumer choice. The current paper discusses some of the important areas where this technique has been successfully used in consumer choice studies. It also discusses some of the technical issues related to proper use and interpretation of this technique.

***Index Terms* – Structural Equation Modelling, Consumer Choice, Modelling**

I. Introduction

Structural equation modelling (SEM) is a statistical technique for testing and estimating causal relations using a combination of statistical data and qualitative causal assumptions (Wright, 1921; Pearl, 2000).

The beauty of Structural Equation Models (SEM) is that they allow both confirmatory and exploratory modelling, allowing them to be used both for theory testing and theory development. Confirmatory modelling usually starts out with a hypothesis represented in a causal model. The concepts used in the model are then operationalized to allow testing of the relationships against the obtained measurement data to determine how well the model fits the data. The causal assumptions embedded in the model often have falsifiable implications which can be tested against the data.

With an initial theory, SEM can use inductive logic to specify a corresponding model and using data to estimate the values of free parameters. The initial hypothesis may require adjustment in light of model evidence. SEM is also used purely for exploration, usually in the context of exploratory factor analysis as in psychometric design.

The major advantage of SEM is the ability to construct latent variables which are not measured directly, but are estimated in the model from several measured variables each of which is predicted to 'tap into' the latent variables. This allows the researcher to explicitly capture the unreliability of measurement in the model, which allows the structural relations between latent variables to be accurately estimated. Factor analysis, path analysis and regression, all represent special cases of SEM.

In SEM, the qualitative causal assumptions are represented by the missing variables in each equation, as well as vanishing covariances among some error terms. These assumptions are testable in experimental studies and must be confirmed judgmentally in observational studies. SEM thus offers interesting options in the study of Consumer Choice due its ability to construct latent variables.

II. Areas of application of SEM in Consumer Choice

Random Utility Theory (RUT) is the underlying concept used to model choice processes (Ben-Akiva and Lerman, 1985; McFadden, 2001). Choice models may be extended by including ideas and methods from structural equation models (SEMs). For example, Elrod and Keane (1997) and Walker (2001) show how to combine covariates with factor analytics to create latent variables that form part of the model specification in explaining discrete choices. The observed variables in SEMs reflect variation in underlying latent variables, known as theoretical constructs, in the measurement sub-model. Regression equations and correlations link the latent variables, in the structural sub-model (Bollen, 1989; Jöreskog and Sörbom, 1996). By including latent variables in this way, one can use SEMs to evaluate and test substantive theory.

The applications of SCM in Consumer choice studies can be divided into three main areas in this paper for better understanding:

1. Applications in Attitude-Perception-Choice Studies: A few examples of this are as follows:

a) Using psychometric data to model attitudes, perceptions and their influences on choices.
b) To explore the links between brand equity, consumer learning and consumer choice processes.
c) Impact of Perceived Product Similarity (PPS) on brand loyalty and word of mouth.

2. Applications in studies of specific behaviour patterns: Examples are:

a) Influence of ethnocentrism and consumer animosity on product judgments and purchase behaviour
b) Exploring relationships between factors influencing ethical consumer choice

3. Applications of SEM in studying consumer behaviour in specific situations or environments: A few examples of such studies are as follows:

a) To propose and test a model that links e-quality dimensions with loyalty and purchasing behaviour in the setting of an online supermarket
b) To explore influences of informativeness, entertainment, and irritation on various online consumer behaviours such as attitude toward the Web, Web usage, and satisfaction

2.1 Applications of SEM in Attitude-Perception-Choice Studies

2.1.1 Using psychometric data to model attitudes, perceptions and influences:

Work in discrete choice models has emphasized the importance of the explicit treatment of psychological factors affecting decision-making (McFadden, 1986). The philosophy behind these developments is that the incorporation of psychological factors leads to a more behaviourally realistic representation of the choice process, and consequently, better explanatory power.

SEM offers a general methodology and framework for including latent variables—in particular, attitudes and perceptions—in choice models. Ben Akiva and his associates suggested a methodology that requires the estimation of an integrated multi-equation model consisting of a discrete choice model and the latent variable model's structural and measurement equations. The integrated model is estimated simultaneously using a maximum likelihood estimator, in which the likelihood function includes complex multi-dimensional integrals. The methodology is applicable to any situation in which one is modelling choice behaviour (with any type and combination of choice data) where (1) there are important latent variables that are hypothesized to influence the choice and (2) there exist indicators (e.g., responses to survey questions) for the latent variables.

They applied this methodology to three examples and demonstrated the flexibility of the approach, the resulting gain in explanatory power, and the improved specification of discrete choice models. Psychometric data, such as responses to attitudinal and perceptual survey questions, are used as by them as indicators of the latent psychological factors. The resulting approach integrates choice models with latent variable models, in which the system of equations is estimated simultaneously. The simultaneous estimation of the model structure represents an improvement over sequential methods, because it produces consistent and efficient estimates of the parameters (Ben-Akiva and Lerman, 1985)

In this framework, as in traditional random utility models, the individual's preferences are assumed to be latent variables. Preferences represent the desirability of alternative choices. These preferences are translated to decisions via a decision-making process. The process by which one makes a decision may vary across different decision problems or tasks, and is impacted by type of task, context, and socioeconomic factors (Gärling and Friman, 1998). Frequently, choice models assume a utility maximization decision process. However, numerous other decision processes may be appropriate given the context, for example habitual, dominant attribute, or a series of decisions each with a different decision-making process. This framework is flexible and can incorporate various kinds of decision processes.

2.1.2 Exploring links between brand equity, consumer learning and consumer choice processes:

The concept of brand equity has interested academics and practitioners for many years, primarily due to the importance in today's marketplace of building, maintaining and using brands to obtain strategic advantage. The concept refers to the idea that a product's value to consumers, the trade and the firm is enhanced when it is associated or identified over time with a set of unique elements that define the brand. Such equity endowments come from current or potential consumer learning which influences how the product is encoded and acted upon by consumers. It stands to reason that such learning is dynamic and influences consumer choice processes and outcomes either directly or indirectly by influencing the effectiveness of the branded products marketing mix elements.

Aaker (1991) defined brand equity as a set of brand assets and liabilities linked to a brand, its name and symbol that add to or subtract from the value provided by a product or service to a firm and/or to the firm's customers. Keller (1993) offered a cognitive psychology perspective, defining customer-based brand equity as the differential effect that brand knowledge has on consumer response to the marketing of that brand. Adopting an information economics view, Erdem and Swait (1998) argue that consumer-based brand equity is the value of a brand as a credible signal of a product's position. More generally, brand equity is often referred to as the added value to the firm, the trade, or the consumer with which a brand endows a product (Farquhar, 1989); or similarly, as the difference between the value of the branded product to the consumer and the value of the product without that branding (McQueen, 1991).

These definitions share the view that the value of a brand to a firm is created through the brand's effect on consumers. Most brand equity conceptualizations are further linked to consumers by emphasizing consumer-based concepts such as brand associations (Aaker, 1991), brand knowledge (Keller, 1993), perceived clarity and credibility of the brand information under imperfect and asymmetric information (Erdem and Swait, 1998). It is clear that brand equity accrues over time via consumer learning and decision making processes. Thus, there is a need to know how consumer learning and choice processes shape and drive brand equity formation.

Erdem et al (1999) attempted to develop a more coherent framework to drive future research on brand equity by (1) initiating an integration of the multiple extant streams of research in branding, brand equity, consumer learning and brand choice, (2) proposing the incorporation of consumer learning theories into models of brand choice and brand equity measurement, and (3) suggesting a possible synthesis of different brand equity perspectives, particularly the signalling and cognitive psychology views. Their framework incorporates the new realities, such as the rise of store brands and electronic commerce, which influence the linkage between brand equity, consumer learning, and choice.

They suggest that, product attributes are selectively encoded and represented in consumer memory in a learning stage. These representations may also be selectively retrieved for subsequent use, for example, in a choice situation. The retrieved attribute representations are assessed evaluative content as in partworths. The utility of the product/service may be derived by combining these partworths using weights that could be idiosyncratic to the individual, product or situation. This process, described above for a single product or service, can work similarly for other products in a category that could belong in a choice set. Choice among the members of this set would depend on the specific decision rule invoked by the consumer.

The multi-staged process described above allows for dynamic consumer learning over time and is effectively modelled using SEM. A new element introduced by Keller is uniqueness which is not directly captured by most multi-attribute utility models. This is an important aspect to branding, with brand strength stemming from points of parity and competitive advantages being generated by points of difference. Krishnan (1996) provides theoretical and empirical evidence of the importance of uniqueness in brand evaluation. In the present framework, one might accommodate uniqueness notions through an increase in the weights attached to the attributes that are perceived to be unique, or by adopting a factor-analytic approach to multi-attribute utility theory.

2.1.3 Impact of Perceived Product Similarity (PPS) on brand loyalty and word of mouth:

The brand clutter in many product categories and increasing numbers of similar products, some of which are deliberate look-alikes, make it more difficult for consumers to distinguish between brands, which can lead to more mistaken and misinformed purchases. Moreover, increasing brand similarity is likely to influence important consumer outcomes.

This tendency to perceive products as similar can result from four scenarios: (1) the pioneer manufacturer brand is emulated by a retailer brand; (2) the pioneer manufacturer brand is emulated by another manufacturer brand; (3) the pioneer retailer brand is emulated by a manufacturer brand; (4) the pioneer retailer brand is emulated by another retailer. From a consumer standpoint, all emulations can cause a problem if consumers are not vigilant and have an orientation to see all brands as similar. In these contexts, consumers often believe they are already familiar with the emulator brand and able to assess it with regard to its attributes and quality and are thus vulnerable to making mistakes (Warlop and Alba, 2004).Walsh and Mitchell (2005) argue 'that when consumers think that all or many products are similar within a category, this can result in mistaken purchases, product misuse, product misunderstanding or misattribution of various product attributes which result in a non-maximisation of utility and consumer vulnerability'. The ability to discriminate between brands has recently been discussed as an aspect of consumers' 'cognitive vulnerability', which Walsh and Mitchell (2005) conceptualise as the consumer's own cognitive limitations to effectively execute a marketing exchange. They developed and tested a PPS scale that could point a new direction in consumer vulnerability research.

Two separate confirmatory factor analyses were performed to test the appropriateness of the items measuring the two constructs. The overall fit for the brand loyalty model was very good. The overall fit for the word-of-mouth model was sound. The examination of the hypothesised relationships between PPS and the two consumer outcomes was tested simultaneously with AMOS 6.0. The global fit statistics indicated that the model represented the data well. PPS had the predicted negative impact on brand loyalty.

2.2 Applications in studies of specific behaviour patterns

2.2.1 Influence of ethnocentrism and consumer animosity on their product judgments and actual purchase behaviour:

At times, imported brands have become linked with animosity and cultural clashes. In an increasingly globalized marketplace, there is evidence that foreign product purchase behaviour vary across cultures (Ang et al. 2004). However, most animosity towards foreign product purchase research has been conducted either in the industrialized countries, e.g. US (Witkowski, 2000), Australia (Ettenson and Klein, 2005), and Germany (Hinck, 2004) or in transition economies (Dmitrov et al. 2009).

Structural Equation Modelling was used to analyse the data in the form of a single-stage analysis with simultaneous estimation of both structural and measurement Models. This method was selected because the model is theoretically based and the latent variables were highly reliable measures (Hair et al. 1998). A correlation matrix was used as the data input because the study focused primarily on delineating the patterns of relationships among constructs, as opposed to explaining the total variance of a construct or comparing the model to different populations.

2.2.2. Exploring the relationships between factors influencing ethical consumer choice:

The growth in concern for ethical issues, which encompass environmental and social concerns, among consumers across countries has been well documented in marketing literature (Shaw and Clarke, 1999). Utilising the Theories of Reasoned Action and Planned Behaviour (Ajzen and Fishbein, 1980; Ajzen, 1985) as a theoretical framework, reliability analysis and structural equation modelling techniques were used by Shaw and Shiu (2000) to uncover the relationships between factors pertinent in ethical consumer choice. Their model incorporates and explores the role of the traditional Theory of Planned Behaviour measures of “attitude”, “subjective norm” and “perceived behavioural control”. Also added to the model are the measures “ethical obligation” and “self-identity” found to be pertinent in consumer decisions where “social” concerns exist (Shaw et al., 2003). Using two data sets a model of ethical consumer decision making was first developed and second, cross-validated.

The proposed model of risk-related choice behaviour: (a) personality has a direct influence on choice behaviour; (b) personality influences choice behaviour via costs and benefits; (c) an integrated model of personality and choice behaviour. Soane et al developed and tested the aforementioned model and examined the relations between a broad range of personality traits and risk-related choice in a range of different situational domains.

2.2.2.1 Structural equation modelling

For each domain structural equation modelling using Structural Equation Modelling Software (EQS) was carried out to investigate the direct associations between the Big Five personality traits and the likelihood of risk-taking, and the indirect associations between the Big Five personality traits and the likelihood of risk-taking (via costs and benefits). The initial model for each domain allowed all five personality traits to predict costs, benefits, and the likelihood of risk-taking, and for costs and for benefits to predict the likelihood of risk-taking. In all cases, the Big Five personality traits were allowed to co-vary as there was some evidence which indicates that these dimensions are not independent (Costa and McCrae, 1992).

2.3 Applications of SEM in studying consumer behaviour in specific situations or environments

2.3.1 To propose and test a model that links e-quality dimensions with loyalty and purchasing behaviour in the setting of an online supermarket:

The pioneers in assessing website quality have been Barnes and Vidgen (2002), and Loiacono et al. (2007). Each of these research teams developed their own scale separately, and both called it ‘WEBQUAL’ (although it was the latter who formally registered the term). However, as Kim et al. (2006) have pointed out, both of these scales focus on the user experience and technical quality of websites, rather than on the quality of the entire service provided.

This stream of research on e-quality has evolved in parallel with a marked increase in online sales, which has triggered a growing interest in the measurement of the quality of online services. Web presence and low prices were previously believed to be key drivers of success (Yang and Fang, 2004); however, it has become apparent more recently that this is not enough (Kim et al. 2006). In these circumstances, instruments such as E-SQUAL might have been expected to attract interest among e-commerce vendors that wish to make an accurate assessment of the quality they are providing to their customers.

The E-S-QUAL scale (Parasuraman et al. 2005) is composed of 22 items arranged in four dimensions for measuring the service quality delivered by online retail websites. The four dimensions are as follows:

1. Efficiency: ease and speed of accessing the site (eight items).
2. System availability: reliable technical functioning of the site (four items).
3. Fulfilment: the extent to which the site's promises about order delivery and product availability are fulfilled (seven items).
4. Privacy: the degree to which the site is safe and protects customer

Information (three items).

An array of exploratory factor analysis was conducted to identify the quality dimensions formed from the data. Before a confirmatory factor analysis (CFA) of the U&G measurement model, an exploratory factor analysis (EFA) was executed by maximum likelihood extraction method, with varimax rotation. In order to decide the number of factors to be extracted and rotated in the U&G model, three methods were used: 1) a cut point of .4 and no significant cross loading criteria, 2) scree plot tests, and 3) consideration of Eigen value magnitude and discontinuity (Hair et al. 1998).

III. Conclusions

The number and variety of applications of SEM indicated above point to the widespread application of this technique in many areas of research including studies of consumer choice. The flexibility of this approach, especially that fact that it can be used both in theory building and theory testing, as well as the fact that it can measure latent variables, makes it an attractive choice for consumer researchers.

However, SEM is far from being a panacea for all intractable problems in consumer research. Unless adequate care is taken to build the underlying logical cause and effect structure which is used the build the models, SEM will not yield the desired results.

3.1 Scales

Many of the variables used in SEM are measured by ordinal scales (Satisfied - Unsatisfied, Terrible - Delighted, Exceed Expectations - Below Expectations). Some researchers apply ratings scales to measure the relevant variables. However, there is no consensus on the appropriate scale to use. Various scales are championed by different researchers citing arguable advantages over competing scales. Given no consensus on appropriate scales for relevant variables, it suggests that the results of studies may be influenced arbitrarily by the type of scale chosen. Additional work on scales (Churchill and Peter, 1984; Wirtz, 2000); relevant to CSD analysis suggest biases with regard to halo effects and a tendency for respondents to suggest satisfaction when this is not the case. In a typical structural equation model, with numerous variables and pathways, bias and error in variable measurement over all variables is likely to compromise model results. Choices avoid these measurement problems and provide a more reliable and realistic scale to measure future brand purchase intentions.

3.2 Multicollinearity

Logic suggests that measurements on perceived performance of attributes (PP) and expected performance of attributes (EP) would be highly correlated. High collinearity of model constructs has important implications for empirical analysis of structural equation models. High collinearity may lead to volatility in parameter estimation. Volatility of sample parameter estimates may lead to false conclusions about significance of model constructs/variables and pathways.

3.3 Estimation and Model Assumptions:

Estimation of structural equation models is done via some recursive regression, multistage regression or confirmatory factor analysis method. In structural equation models, typically estimated using confirmatory factor analysis, identification of principal components of the correlation or covariance matrix is a key element. The covariance and/or correlation matrices need interval or ratio scaled measurement of constructs for validity. However, as argued earlier many of the constructs measured are not interval or ratio but more likely to be ordinal. The correlation/covariance matrix may not be a valid representation of the association of model constructs. Analysis based on decomposing the covariance/correlation matrix may also not be valid. A similar argument applies to regression based techniques for estimation. Using ordinal scales for model constructs may invalidate typical estimation of structural equation models.

In addition, assumptions about model disturbances are unlikely to hold for ordinal scaled measures particularly when they are used as dependent variables in equation structures. Inference about population structure depends crucially on non-violation of disturbance assumptions. Violation of disturbance assumptions may lead to inefficient or biased estimates or both. Inference from estimation may be invalid. Given violations of estimation assumptions outlined above, typical estimation of many models including structural equation estimation are likely to have low statistical power. Low power increases the likelihood of erroneous conclusions about construct associations, significance of constructs and significance of pathways. Suggested implications for management practice are likely to be flawed and recommended actions and strategies inferred from models may be erroneous.

However, Choice model frameworks are based on less rigorous assumptions and are likely to be more reliable. In general, it is obvious that, used with due care, SEM provides a very useful tool to researchers of Consumer Choice studies as with many other areas of research.

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