APPLYING FISHBEIN'S MULTI-ATTRIBUTE ATTITUDE MODEL TO THE TATA SWACH WATER PURIFIER

Ricks, Sean T; Winter V, Amos G
Massachusetts Institute of Technology, United States of America

Abstract

In this paper, user feedback is used to calculate the relative importance of several attributes of a water purifier by applying Fishbein's Multi-Attribute Attitude Model. Survey data is collected from 35 users of a particular water purifier in India. Their beliefs regarding 10 attributes and their overall attitude toward the product are quantified. Least squares regression is used to calculate the relative importance of each attribute to the average user, and a comparison is made between users' reported overall attitude and that predicted by the Fishbein model. Though some results are inconclusive, it is shown that filter efficacy and ease of maintenance may be the most important factors in determining user attitude toward the purifier. Limitations of the Fishbein model in this context are discussed including the fact that this model assumes that all attributes are linearly related to overall attitude. It is recommended that more data be collected and the model be expanded before these findings are used to inform future design decisions.

Keywords: Early design phases, Ranking customer needs, Design for the developing world, Research methodologies and methods

Contact:
Sean Thomas Ricks
Massachusetts Institute of Technology
Mechanical Engineering
United States of America
sricks@mit.edu

Please cite this paper as:
Surnames, Initials: *Title of paper*. In: Proceedings of the 20th International Conference on Engineering Design (ICED15), Vol. nn: Title of Volume, Milan, Italy, 27.-30.07.2015

1 INTRODUCTION

One of the key challenges of any consumer product development process is understanding design requirements imposed by the consumer. In order to create products which will meet user needs and be acceptable to the consumer, designers must understand which attributes of a product are valued by the consumer. When trade-offs need to be made during a development process, it is vital to know how changing each parameter of a product will affect its acceptability to the consumer.

To aid in this task, researchers have proposed a variety of models to represent how consumers evaluate products and make decisions. One of the earliest and most widely known models is Fishbein's Multi-Attribute Attitude Model which states that a person's overall attitude toward an object is the sum of his or her belief concerning each salient attribute of the object weighted by the importance of that attribute (Fishbein, 1963). Represented mathematically, this is:

$$A_o = \sum_{i=1}^{N} b_i e_i \quad (1)$$

where A_o is the overall attitude toward the object, b_i is the strength of the belief that the object has attribute i, e_i is the importance of attribute i, and N is the number of salient attributes. In prior research, Fishbein's model has been applied to consumer products and used as a means of anticipating consumer brand preference (Bass and Talarzyk, 1972). In this study, Fishbein's model will be applied to consumer preferences surrounding a household water purifier. Data on consumers' beliefs concerning 10 salient attributes of the purifier and a measure of their overall attitude toward the product will be used to back-calculate the relative importance of each attribute. Understanding the relative importance of each attribute will aid designers as they make future iterations of the product and attempt to improve overall acceptability to the consumer.

The purifier which is used in this study is the Tata Swach — a purifier which is manufactured and marketed by Tata Chemicals, Ltd. in India. Because of a lack of municipal infrastructure throughout the country, the use of home purifiers to treat potable water is necessary. The Tata Swach (shown in Figure 1 below) has been on the Indian market since 2010 and costs approximately 20 EUR.

Figure 1. The Tata Swach purifier in a user's home

Unlike many other more expensive purifiers in that market, the Tata Swach is gravity driven and thus does not require electricity. Also unlike many other purifiers, the Tata Swach is effective only against biological contaminants and cannot be used to remove chemicals or dissolved solids from the water.

To use the Swach, water is poured into the top container through a microfiber mesh which removes large particulates. From the top container, gravity drives water through the filter element which contains carbon and silver nanoparticles which filter and purify the water. Clean water is then deposited in the lower container where it is stored until consumed by the user.

It is the aim of this study to use Fishbein's model to calculate the relative importance of each of 10 attributes of the product to consumers' overall attitude towards the product.

2 DATA COLLECTION PROCEDURE

2.1 Survey Administration

Data for this study were collected through the verbal administration of surveys by the researcher and a local translator in the homes of current Tata Swach users in India. The surveys were conducted in the language that the respondent was most comfortable speaking. Translators were local students or young professionals who were native speakers of the regional languages. They were trained by the researcher in the purposes of the study and coached in the manner in which questions should be asked in order to ensure consistency and minimize bias. Each interview was supervised by the lead researcher to ensure quality.

2.2 Survey Description

Each survey contained approximately 65 questions (the use of some questions was dependent on responses to previous questions) and required about 25 minutes to complete, though some interviews lasted as long as 40 minutes depending on the level of detail provided by respondents. Questions were primarily short answer and multiple choice and covered topics from basic water-use habits to product-specific feedback to demographics. The 11 questions pertinent to this analysis are shown in Table 1.

Table 1. Survey questions

Question	**Options Provided**
1. How would you rate the quality of your *filtered* water?	(1) Very Bad, (2) Bad, (3) Adequate, (4) Good, (5) Very Good
My water filter:	
2. Filters water quickly.	(1) Agree, (2) Disagree, (3) No Opinion
3. Has a good storage unit size.	(1) Agree, (2) Disagree, (3) No Opinion
4. Is easy to maintain.	(1) Agree, (2) Disagree, (3) No Opinion
5. Is easy to get parts for.	(1) Agree, (2) Disagree, (3) No Opinion
6. Replacement parts are affordable.	(1) Agree, (2) Disagree, (3) No Opinion
7. Is durable/does not break.	(1) Agree, (2) Disagree, (3) No Opinion
8. Improves my water's taste.	(1) Agree, (2) Disagree, (3) No Opinion
9. Improves my water's colour.	(1) Agree, (2) Disagree, (3) No Opinion
10. Improves my water's smell	(1) Agree, (2) Disagree, (3) No Opinion
11. How would you rate the product as a whole?	Score out of 5

All of these questions were asked with respect to the Tata Swach which respondents were currently using (or had been using in the recent past) in their homes. The survey was administered to a total of 39 participants, though only 35 participants provided answers to all 11 of these questions and could therefore be included in this study.

As will be described in Section 3, each of the questions 1 through 10 describes a particular attribute which will be considered salient to determining the respondent's overall attitude towards the product. The inclusion of these particular attributes and the exclusion of others is the result of a couple of factors. First, an exploratory study was performed by the researcher in the months preceding this study with the aim of identifying salient attributes. In the exploratory study, four individuals of Indian origin who were living in the Boston, Massachusetts, USA area were given a Tata Swach to use in their homes for a week. The researcher met with each participant at the beginning of the study to observe as he or she attempted to assemble the product and use it for the first time without guidance and again at the end of the study to interview the participant about his or her background and experience with the product. Each of these interviews lasted approximately 40 minutes and was very open-ended, asking participants to describe the product and comment on any problems they may have had with it throughout the week. The interviews were recorded, transcribed, and analysed qualitatively to find attributes which the participants considered important. Second, a portion of this current study was performed in partnership with the Comprehensive Initiative on Technology Evaluation (CITE) at the Massachusetts Institute of Technology (MIT). CITE researchers prepared a survey to evaluate filter use in India, and upon comparison with results from the exploratory study, this researcher found that most emergent themes in the qualitative data were covered in CITE's survey. In the end, this

researcher determined to move forward with a slight variation of CITE's survey in order to facilitate information sharing across studies. Each of the questions from Table 1 are found in CITE's survey.
Open-ended questions included in the survey such as "What do you like/dislike about the filter?" yielded rich qualitative data that will likely lead to the identification of other salient attributes in the future. Analysis of these data could not be included in this study, however, because they are not consistent across respondents (e.g. though many commented on the portability of the product, it cannot be analysed in a meaningfully quantitative way because it was not identified beforehand as a salient attribute and was therefore not asked explicitly of every respondent).

2.3 Survey Location

Surveys were administered in two geographic locations in India: Ahmedabad, Gujarat and Mumbai, Maharashtra. Of the 35 respondents included in this analysis only one was in Ahmedabad so the effect of geographic location on overall results should be minimal. Nevertheless, for the sake of completeness, a short explanation of the difference in use context between these two locations is provided.
Ahmedabad experiences a level of groundwater salinity that is much greater than that experienced by Mumbai. As shown in Figure 2, Mumbai experiences total dissolved solids (TDS) levels below 480 mg/L whereas Ahmedabad experiences TDS levels greater than 1920 mg/L.

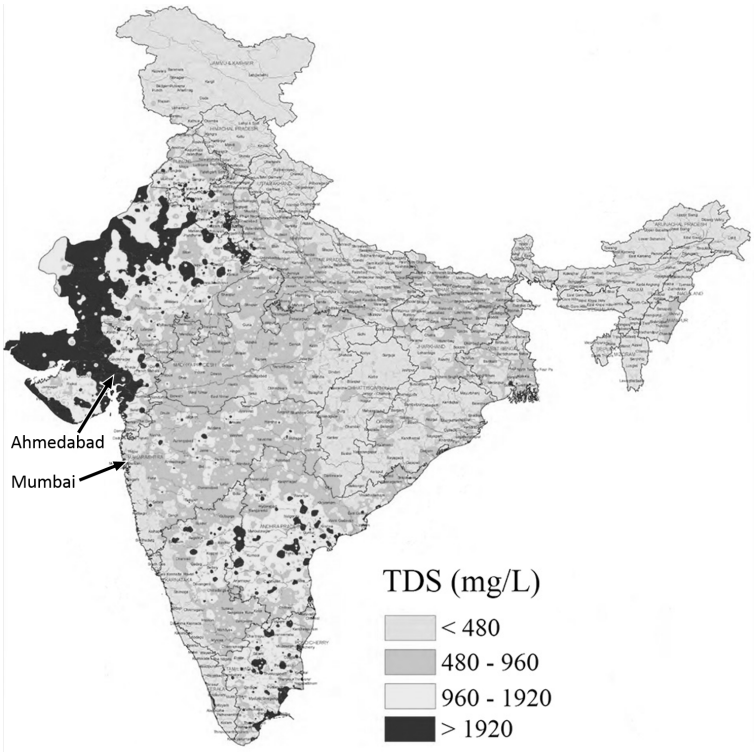

Figure 2. Groundwater salinity in India. From Central Ground Water Board

In addition, the provision of treated water from the municipality was ubiquitous in Mumbai, whereas many people in Ahmedabad obtained their water from an untreated source provided by a third party such as a private bore well. Survey respondents in Ahmedabad would often describe their water as salty, and as a result, the use of reverse osmosis filters (which have the ability to remove dissolved solids) was much more dominant in Ahmedabad as compared to Mumbai. As the Tata Swach is not a desalinating purifier, it would possibly experience a disadvantage in questions 1 and 8 with respect to an equivalent evaluation in an area which does not have issues with high TDS levels.

2.4 Identification of Participants

Survey participants were identified through Tata Chemicals which provided the contact information for Swach users who had recently contacted the customer support centre. These are individuals who were requesting service for their product either because they were experiencing a problem or because it was time for their regularly scheduled filter element replacement. These individuals were then

contacted by the researcher and asked if they would be willing to participant in the survey. This selection process incorporates a definite bias since these individuals are much more likely to have experienced a recent malfunction of the product than the average user. It would not be valid, therefore, to claim that the *experiences* of these individuals is representative of all Swach users. However, this researcher believes that it is fair to claim that the *preferences* of these individuals with regard to attributes can be representative of a greater population of Swach users. In any case, this bias should be considered by anyone who seeks to apply the results of this study to a population.

3 ANALYSIS AND RESULTS

3.1 Choice of Proxies

Fishbein's Multi-Attribute Attitude Model says that a person's overall attitude toward an object is the sum of his or her beliefs regarding each of its salient attributes multiplied by that attribute's respective importance (Fishbein, 1963). In this study, responses to questions 1 through 10 are considered to be the respondent's beliefs regarding 10 different salient attributes of the filter. There are most likely other salient attributes which are not captured in those questions, however reliable quantitative data for other attributes are not available in this data set and must therefore be ignored.

The response to question 11 is considered to represent the respondent's overall attitude toward the product. This is a reasonable assumption as long as respondents answered honestly and thoughtfully. Researchers may be tempted to use responses to other questions regarding purchasing or recommendation behaviour as proxies for overall attitude towards the product (e.g. if the respondent has recommended the product to friends, it is an indication that his or her attitude towards the product is positive), however this practice would be incorrect. It has been emphasized in the literature that attitudes toward an object must be distinguished from attitudes toward *using* (or recommending, for that matter) an object because different salient attributes may apply to each (Tuck, 1973). Thus, because this study seeks to quantify each respondent's attitude toward the product, it is most appropriate to use a proxy which points directly at the product, as in question 11.

Calculation of the importance of each salient attribute is the subject of this analysis.

3.2 Quantifying the Data

In order to apply the data to the Multi-Attribute Attitude Model, it is necessary to convert the data from qualitative statements of belief about each attribute (e.g. "I agree that my filter is durable") to numerical values. This is fairly straightforward for questions 2 through 7. Table 2 shows the possible responses and their corresponding numerical value.

Table 2. Numerical assignments for responses to questions 2 through 7

Response	Numerical Value
Agree	1
No Opinion	0
Disagree	-1

This is consistent with value schemes used by other researchers (Pohlmeyer, 2012).

A similar scheme is used for questions 8, 9, and 10 except that all responses of "Disagree" are counted as "No Opinion" (i.e. valued 0). This is because most respondents who answered "Disagree" qualified their responses to those questions by saying that their water was already within acceptable bounds with regards to colour, taste, and smell so they did not expect it to change. It became clear that their responses were meant to be neutral rather than an indication that a wanted attribute was missing.

For question 1, the responses are first remapped to a -2 to 2 scale and then normalized to have an equivalent range to the other attributes. The reason for normalizing is to ensure that weighting factors calculated for each attribute are comparable. The resulting value scheme is shown in Table 3.

Table 3. Numerical assignments for responses to question 1

Response	Numerical Value
Very Good	1
Good	0.5
Adequate	0
Bad	-0.5
Very Bad	-1

For question 11, the overall satisfaction score out of 5 is remapped to a -2 to 2 scale for the sake of symmetry between the attributes and the overall attitude. It is allowed to retain its wider range in order to provide resolution in the final attitude score which will be calculated. The resulting value scheme as well as a descriptive interpretation of the attitude score is provided in Table 4.

Table 4. Numerical and descriptive assignments for responses to question 11

Response (Score out of 5)	Numerical Value	Description
5	2	Very Satisfied
4	1	Satisfied
3	0	Neutral
2	-1	Dissatisfied
1	-2	Very Dissatisfied

Because the respondents were only asked for a score out of 5 and were not asked to describe in words their overall opinion of the product (e.g. “Satisfied”, “Dissatisfied”, etc.), an important assumption is made here that a respondent would equate a score of 3 out of 5 to an indication of neutrality and likewise with the other scores. This may be a valid assumption to make when the survey respondents are familiar with using a Likert scale. If they are not, it may not be a valid assumption, and the numerical values should not be translated to words. In any case, it must be understood that a score of 0 out of 5 is not a valid response.

3.3 Calculation of Attribute Importance

In order to calculate the importance of each attribute, a critical assumption must be made that an attribute’s importance is constant across all 35 respondents. This is, of course, untrue as each respondent has unique preferences and would allocate importance in a unique way. However, since the goal of the study is to understand preferences *in aggregate* it makes sense to make this assumption. Results therefore represent the importance that an *average* consumer assigns to each attribute. Using mathematical software, a least squares regression was performed across 35 linear equations of 10 independent variables. The resulting coefficients are the importance values of each attribute and are summarized in Table 5.

Table 5. Average importance of each attribute

Attribute	Importance
1. Quality of filtered water	1.45
2. Filters water quickly	0.22
3. Has good storage unit size	0.30
4. Is easy to maintain	0.43
5. Is easy to get parts for	0.24
6. Replacement parts are affordable	0.00
7. Is durable/does not break	-0.18
8. Improves the taste of water	-1.02
9. Improves the colour of water	0.20
10. Improves the smell of water	-0.01

These values, then, represent the relative weight that the average user places on each salient attribute when determining overall attitude toward the product.

3.4 Analysis of Fit

To evaluate the accuracy of these values, they are substituted back into Equation 1 and used to predict an overall attitude score for each respondent. This score is compared with the score the respondents reported (i.e. their responses to question 11 remapped as in Table 4) to determine if overall attitude was consistently predicted by responses to questions 1 through 10 and the calculated importance factors. Figure 3 shows this comparison where the data have been sorted from lowest reported score to highest in order to facilitate visually interpreting the fit.

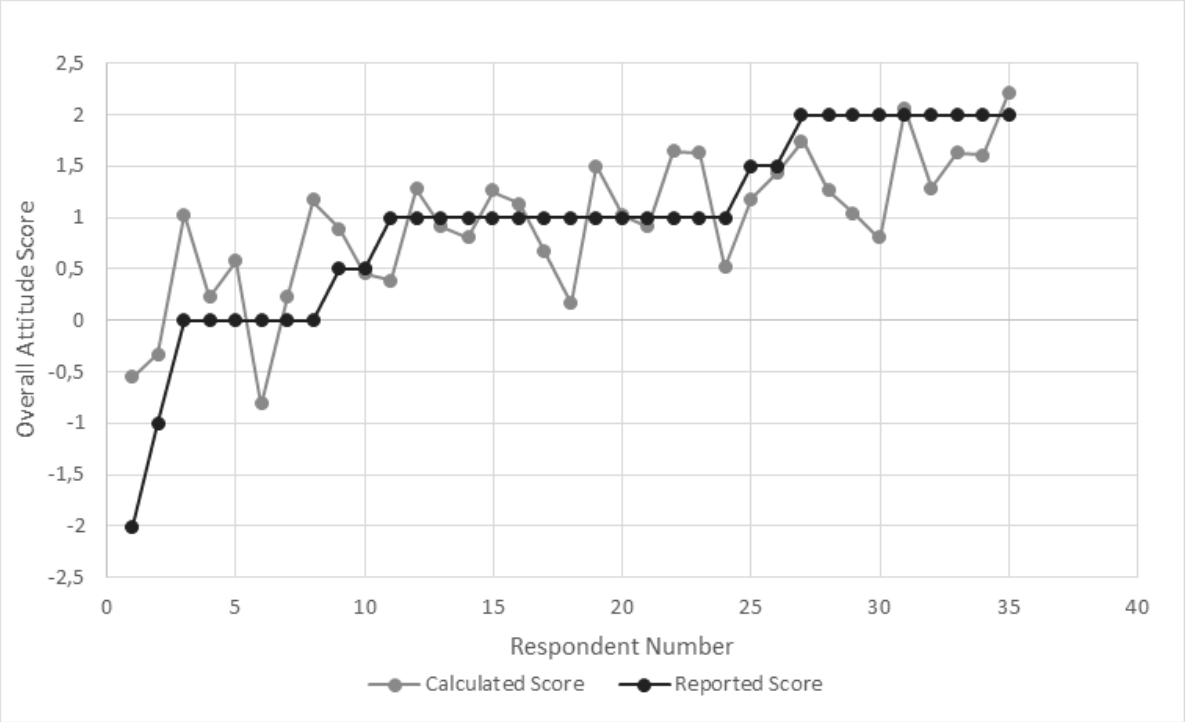

Figure 3. Comparison of overall attitude scores reported by respondents and calculated using experimentally determined importance factors

As can be seen from the figure, Fishbein's model using the calculated weights is able to predict overall attitude fairly accurately in many instances. The average of the absolute (unsigned) error is 0.49 and the standard deviation of the same is 0.37. In some instances, however, the prediction was not very accurate, and the maximum error observed in this data set is 1.45.

4 DISCUSSION

4.1 Significance of weights

The values in Table 5 reveal some interesting insights. First, "quality of filtered water" scored an importance rating of 1.45 which was significantly larger than all of the other importance ratings. This means that according to this analysis, the filter's efficacy in improving water quality has a greater impact on overall attitude towards the product than any other attribute. This would suggest that designers should focus their efforts on improving the technical performance of the filter, though further inquiry may be necessary to determine which factors consumers consider to determine the quality of the water (e.g. expected contaminant levels, aesthetics, etc.).

The second most important attribute is "ease of maintenance" with a score of 0.43. From the qualitative data, some factors that were mentioned that could affect attitude toward this attribute are:

1. Ease of cleaning the microfiber mesh filter
2. Resistance of plastic parts to algae growth
3. Number of parts
4. Life of filter element

These represent potential areas for design improvements that could have a significant impact on overall satisfaction.

Another interesting finding is that the attribute "replacement parts are affordable" scored an importance rating of 0. This would suggest that this attribute has no connection to overall attitude toward the product, a finding which was not expected. One possible explanation for this is that respondents to the survey may have not yet experienced a need to replace any parts and therefore did not consider this a salient attribute. Though nearly all of the respondents had replaced a filter element at some point, it is possible that they did not associate this disposable part with a "replacement part" because it was something that was merely used up rather than something that broke and had to be replaced.

The fact that three importance ratings came out negative ("is durable", "improves taste", and "improves smell") is a problem. Though Fishbein's model does allow the existence of negative weights, these weights should be associated with negative attributes so that the lack of such an attribute contributes positively to overall attitude. In this case, common sense indicates that durability and improved water aesthetics should not be considered negative attributes. The score for "improves smell" is nearly zero so it can perhaps be discounted, however the other two scores are not so easily ruled out. One possible explanation is that there is an extraneous variable that is not being considered which is leading to the correlation. For example, though unlikely, it is possible that there exists a positive feeling among the respondents associated with fixing something that could lead respondents who have experienced breakages to have a more positive overall attitude toward the product because they have fixed it. A more likely explanation is that salient attributes are missing from the analysis which, when included, would drastically change the allocation of relative importance. If this is the case, it calls into question the validity of all of the other importance ratings as well. A third possible explanation is the sample size may not be large enough and the negative weights could be the result of randomness. In any case, it is obvious that further analysis is necessary before conclusions can be reached with confidence.

4.2 Improving Existing Model

To improve the model, more data should be collected in order to increase the sample size and decrease the effects of randomness. At that point, a more robust statistical analysis could be performed to determine the statistical significance of the several identified salient attributes. A second round of data collection would also allow the addition to the model of new salient attributes that were identified in the qualitative portions of the survey but were not able to be included in this analysis. It is anticipated that this would increase the accuracy of the calculated importance factors.

4.3 Model Limitations

There are a few limitations which are inherent to the application of the Fishbein model to a product. First, the Fishbein model does not include a constant term. This term would account for any offset in the reported overall attitude that is constant across respondents. This is especially important when considering the difference between *reported* attitude and *actual* attitude (i.e. respondents may tend to report overly positive attitudes if they anticipate that the survey administrator is in some way associated with the product).

Second, the Fishbein model assumes a linear relationship between salient attributes and overall attitude. This is in disagreement with other models such as the Kano model which suggests that some attributes (namely "attractive qualities" and "must-be qualities") relate to customer satisfaction in an exponential way (Kano, 1984). If any of the salient attributes investigated in this study fall into the "attractive" or "must-be" categories as defined by Kano, the effect would be missed and the fit of the model would be negatively impacted.

4.4 Future Work

Future work should focus on improving the statistical robustness of the analysis so that conclusions may be reached with greater confidence. This involves collecting more data to increase the sample size as well as quantifying the new salient attributes identified in the qualitative portions of the survey.

Another interesting line of inquiry would be to investigate the effect of demographics on filter users' allocation of importance. Do users from different economic classes consider different attributes to be most important? This data set is too small to investigate this question with any statistical significance, but with a larger data set, this question could be investigated by back-calculating importance factors

for different subsets of individuals. This could lead to interesting insights into how to target different market segments.

5 CONCLUSION

This paper has shown how the Fishbein Multi-Attribute Attitude Model can be applied to a data set for users of the Tata Swach water purifier. Using respondent's answers to 11 questions (10 regarding salient attributes and 1 regarding overall attitude toward the product), the relative importance of each salient attribute was calculated by least squares regression. Though the results are inconclusive, there is some indication that "quality of filtered water" and "ease of maintenance" are important attributes from the customer's perspective. After collecting more data to verify these findings, this information may be useful to designers because it can help them understand customers' prioritization of design requirements and inform design decisions for future iterations.

REFERENCES

Bass, F. M. and Talarzyk, W. W. (1972) An Attitude Model for Study of Brand Preference. Journal of Marketing Research, Vol. 9, No. 1, pp. 93-96.

Central Ground Water Board. (2010) Ground Water Quality in Shallow Aquifers of India. Technical report, Government of India.

Fishbein, M. (1963) An Investigation of the Relationships between Beliefs about an Object and the Attitude toward that Object. Human Relations, Vol. 16, No. 3, pp. 233-239.

Kano, N., Seraku, N., Takahashi, F., and Tsuji, S. (1984) Attractive quality and must-be quality. The Journal of the Japanese Society for Quality Control, Vol. 15, No. 2, pp. 39-48.

Pohlmeyer, A. (2012) Identifying Attribute Importance in Early Product Development: Exemplified by Interactive Technologies and Age, Berlin, Technical University of Berlin.

Tuck, M. (1973). Fishbein Theory and the Bass-Talarzyk Problem. Journal of Marketing Research, Vol. 10, No. 3, pp. 345-348.

ACKNOWLEDGEMENTS

The author would like to thank Tata Chemicals, Ltd. for their participation in this study. Also, the Tata Center for Technology and Design at MIT for funding this research. And Jesse Austin-Breneman (MIT) and David Taylor (MIT) for their contributions.