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Consumer Expectations from the Internet of Things: A study on Smart Home Products

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Abstract: **In a world where the Internet of Things is becoming a center of interest of all researchers, domotics or smart home products has demonstrated itself as one of the hottest trends to follow. Smart homes are homes equipped with highly advanced systems that monitor and control the multiple functions of the home and that allow the home devices to interact with each other and with the householders at the same time. The purpose of this thesis first is to identify the main important attributes of smart home products, then to investigate the consumer expectations from these products by using the conjoint analysis method. The findings of this research have shown multiple area of development. The ideal smart home product profile for the 155 investigated respondents was one with high privacy and security, extreme usefulness and reliability, moderate interoperability and low cost. The Marketing Engineering Software for Excel was used in order to estimate part worths for the conjoint analysis and the attribute importance. Respondents had shown a high importance for privacy and security and then usefulness in which they represent more than 50% of the attributes importance, then come reliability and price and at the end interoperability. Market shares were predicted by using the First-Choice Rule for 9 existing product profiles; the ideal product for consumers was the Inseton Hub Central Controller with a high privacy and security, extreme usefulness and interoperability, moderate reliability and a low cost, with 30 % of the market share. The results demonstrate that modifying costing and promotional strategies as well as working on some technical areas of the smart home products such privacy and security and interoperability could increase market share for smart home products producers.**

Keywords: **Conjoint Analysis, domotics, internet of Things, interoperability, reliability smart home, security and privacy, usefulness.**

1. INTRODUCTION

The issue to be solved in this study is that Smart Home Products' companies do not specifically know what consumers expect from their products and what are the variables that may fill the existing demand gaps among the consumer and give him a rational push to make a purchase. This research has the purpose to answer these questions, because understanding the consumer behavior and intentions toward a product, will allow the companies to provide the adequate product which benefit all the parties concerned and lead to their satisfaction. The purpose from doing this research is to study the consumer expectations regarding the Internet of Things more precisely the smart home products. Consumer expectations will be studied by using the conjoint analysis method since it is one of the practical methods to imitate real-life scenarios and help researcher to understand more the consumer preferences, also it is the most generally used method for studying the consumer trade-offs [1].

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2. RESEARCH METHDOLOGY & FINDINGS

2.1 Conjoint analysis

When coming to the literature of the conjoint analysis, [2] discussed shortly the conjoint methodology in their working paper, the more detailed paper didn't become visible till 1971 [3]. After that, a series of articles discussing applications or algorithms appeared in different journals [4], [5], [6]. The multiattribute modeling of consumer preferences' theoretical justification was supplied in the growing literature on the expectancy-value models and the new economic theory of consumer choice' Fishbein-Rosenberg class [7], [8]. Due to the considerable number of preferences variation among consumers, conjoint analysis is generally conducted at the consumer level. The preference model form is usually supposed to be the same for all respondents, but the model parameters are allowed. Different alternate ways exist in order to identify the attributes that are pertinent to respondents in order to form their preferences [9]. An initial data collection effort, asking consumers concerning attributes that are important to them, generally facilitate the identification of those attributes that are most regarded as pertinent [10]. Focus group interviews, or Kelly's (1955) repertory grid, or opinions of product managers, retailers and others who got a good knowledge about the goods and/or services and their use can be applied for this purpose. The hardest task in conjoint analysis is the reduction of the attributes' number to a size that could be managed so that the procedures of estimation are more reliable meanwhile accounting for consumer preferences sufficiently well.

Conjoint analysis is considered as a multivariate technique that is precisely used in order to understand the respondent's preferences development [11], more precisely, the technique in hands is generally used in order to analyze how respondents assess the global profile part worth by supposing that they take all the product's attributes in consideration and pick the one with the more elevated part worth score [3].The conjoint analysis is a method that is used for the purpose of modeling multilevel dependent variables, in this method, the impact of independent variables on the dependent variables are possibly to be measured [12], [13].

The goal of this study is to check what is the combination of characteristics of the smart home products' the most needed by consumers. Therefore, a part-worth utility model is chosen to be used in this ongoing study. This model turned it to be possible to count every attribute's levels as numerical partworths values [14]. For data collection, a Full- Profile approach has been used in order to retain the conjoint factual in a maximum way. By using this method, consumers pick between various products that are having the entire attributes that have been given. The two-factor-at-a-time method is a different choice in which consumers are supposed to put different factors' sets by order. The full-profile approach provides to the stimuli a more factual designation and this is by identifying each attributes levels and possibly consider the environmental correlation among characteristics in real stimuli [15].

In case if the full factorial design is used, respondents were supposed to be exposed to 243(35), which is not possible. For that reason, the orthogonal design is used in this study in order to minimize the number of profiles. Since, it was not obligatory to get outcomes on all the possible sets [16]. The objective of researchers from finding such a design was the balance that is has, differently saying, each level in each attribute appears the same number of times, and the one that was orthogonal, that is if you get a pair of levels, one from an attribute and one from another one, the pairs appear the same number of times in the array [17]. For respondents, orthogonal design is advantageous. First, because it takes less time in order to fulfill the survey. Yet the orthogonal design permits the principal attributes impact in the conjoint analysis to be weighted. Eventually, nevertheless some profile cards remain not realistic, the orthogonal design gives an optimal prediction [18]. These combinations are more explained, later in this chapter. The orthogonal design tool of the conjoint analysis module of Marketing Engineering for Excel version 2.1.0. reduced the combinations' number to sixteen (16) bundles. Orthogonal design has been studied since the conjoint analysis' early years. While using it in metric analysis, it remains as a strong design [19].

Respondents may see all the product features as important, and it would be quite difficult for them to give a relative importance of a key product characteristics' number [20]. For that reason, a choice-based conjoint has been chosen to be used in this study in order to facilitate the task for respondents and rank the bundles from 1 (most preferable) to 16 (less preferable) by preference.

2.2 Attributes

This research is concentrated on smart home products, because their revenue in the national market (Turkey) is expecting a real growth from US$303m in 2019 to US$914m by 2023, which is a growth of 31,8% [21]. Therefore, it was expected that, this IoT segment which are the Smart Home Products, are more likely to be recognized by respondents.

The attributes used in this research were taken because they are considered as the most important characteristics of a smart home product. The TABLE 1., demonstrates every attribute level mentioned in this study.

TABLE 1. CONJOINT ANALYSIS DESIGN

Attributes/ levels	Level 1	Level 2	Level 3
Privacy and Security	Impossible	Moderate	High
Reliability	Not At All Reliable	Moderately Reliable	Extremely Reliable
Usefulness	Not At All Useful	Moderately Useful	Extremely Useful
Interoperability	Not At All Interoperable	Moderately Interoperable	Extremely Interoperable
Cost	Low	Moderate	High

As mentioned before, five attributes were considered: privacy and security, reliability, usefulness, interoperability and cost. The way how smart homes function, allow them to collect data about the householders in order to assist them the best way [22]. However, the insurance of an adequate saving of the householders' personal data is very important. In this study, this attribute had given three level: Impossible for a no privacy and security preference, moderate for a moderate privacy and security preference, high for an extreme level of privacy and security. According to [23], Reliability is the main challenge as this attribute will support the user-friendliness and empowerment and smart homes shouldn't fail or do unexpected things, in a sort that smart homes are expected to function as they have to. Three levels have been affected to this attribute as mentioned in the Table 3.2. Functionally, smart homes are meant to manage the daily living demands of householders through the use of technology. Smart homes are considered as useful when they are introduced to the householders as evident and forked: security, convenience through automation, comfort, scheduling tasks, efficiency and energy management; and for particular end-users, assisted living and health [24], [25], in this research, three levels are affected to this attribute in order to study the consumer preference. Interoperability is one of the most challenging topics for researchers in the IoT era, it is the key to open new markets to competitive solutions in IoT is definitely the interoperability [26], [27]. Currently, the main objective for the leaders in the smart devices manufacturing, is to achieve a full interoperability that will ensure easy integration with the existing internet. Smart homes can be totally interoperable which means they can get connected with any other brand's devices, moderately interoperable with some other brand's devices or not at all interoperable which means It is interoperable only with the same brand devices. Cost is considered as one of the main concerns of the customer, in order to study the consumer expectations regarding the smart home products, three cost levels are affected: low, moderate and high cost.

2.3 Demographics & findings

In this study, a conjoint analysis has been conducted in order to determine the best profile combination that suites the consumer expectations regarding the smart home products. In combination with it, a demographical survey has been conducted in order to study the demographical factors of the respondents from gender, age, education, marital status and income.

A. Sample size

The sample size in conjoint analysis is variable. When the conjoint analysis is for a commercial use, the sample size generally varies between one hundred and one thousand respondents. When going for conjoint analysis studies that contain a lower number of variables, the sample size goes mostly between one hundred and one hundred and fifty, with an average of 138 respondents [28]. In the current research, five variables are utilized, for that reason and for having a representative analysis the sample size was 155 respondents.

B. Data source

A survey was conducted using Marketing Engineering for Excel version 2.1.0 for data design for the conjoint analysis. TABLE 1., represents the survey design used in this research. The survey was distributed to 155 respondents between February and March 2019. Those respondents are all Istanbul Aydin University Students. Before the distribution of the

survey a 10 minutes' presentation is done in order to explain the topic and the way of fulfillment of the survey. The data collected has been manually entered to the Marketing Engineering for Excel version 2.1.0. after a data collection template had been created. After entering the data, respondents' preference partworths has been estimated and then an analysis has been run and eventually results has been obtained.

C. Findings

The target group for this survey was students of Istanbul Aydin University, aged between 18 and 54 years. The data was collected by the help of my Advisor Assoc. Prof. (Ph.D.) İLKAY KARADUMAN and Assist. Prof. Dr. NURGÜN KOMŞUOĞLU. The survey was set up in December 2018 and was handed out between February and March 2019 to 258 students, from which 155 fully responded (response rate of 60%). The incomplete or invalid responses were taken away, so the data set consisted of 155 responses. During the data collection, it was noticed that, in order to give valid responses, the respondents spent between 10 to 12 minutes to complete the survey correctly. Otherwise, when the respondent spent less than 5 minutes on completing it, generally the answers are not carefully done.

About demographics, 69% of the valid and completed surveys were done by males aged between 18 and 54 years and only 31% by females aged between 18 and 34 years only 8% of them are married and the rest is single (TABLE 2, 3 AND 6). Most of the respondents were bachelor students, in which 70% were bachelors and 30% were master students. 46% of the respondents are considered to have a minimum income between 0 and 1603TL, 21% are between 1604TL and 3000TL and the rest are above the 3000's. The tables below summarize the key statistics about the participants.

TABLE 2. STATISTICS ABOUT RESPONDENTS: GENDER

Male	Female	Undisclosed
69%	31%	0%

TABLE 3. STATISTICS ABOUT RESPONDENTS: AGE

0-17 Yo	18-24 Yo	25-34 Yo	35-44 Yo	45-54 Yo	55-64 Yo	65-74 Yo	Yo>75
0%	77%	21%	1%	1%	0%	0%	0%

TABLE 4. STATISTICS ABOUT RESPONDENTS: EDUCATION

No schooling	Primary school	High school	University	Masters	PhD.	Undisclosed
0%	0%	0%	70%	30%	0%	0%

TABLE 5. STATISTICS ABOUT RESPONDENTS: MARITAL STATUS

Single	Married	Undisclosed
90%	8%	2%

TABLE 6. STATISTICS ABOUT RESPONDENTS: INCOME

0-1,603TL	1,604-3,000TL	3,001-5,000TL	5,001-8,000TL	Above 8,000TL	Undisclosed
46%	21%	5%	3%	3%	23%

2.4 Conjoint Analysis: Findings

The conjoint analysis is considered as a tool that shapes the origin of consumer compromises between different attribute goods or services. It comes with an assumption that substitutional product ideas can be explained as a chain of defined levels of a common set of attribute. It presumes as well that the global part-worths that the consumer obtains from a good or service is defined by the part-worths or utilities participated by every attribute level. The conjoint analysis begins with the general idea of a consumer regarding a group of complicated alternatives [29]. After that, it carries out a decomposition of the consumer's main judgments into separate and appropriate part-worths scales, by which the main general ideas can be rebuilt. Having the ability to detach the consumer's general evaluations into components, in this way,

can give the producers important data regarding relative different attributes importance of a good or service. It also has the ability to give data regarding the different levels value of an attribute. Thus, the conjoint analysis goal is to define the attribute combination that provide the highest part-worths to the consumer and to set up the attributes relative importance in terms of their participation in the total part-worths. Eventually, a perfect product profile can be evaluated.

In this study 16 alternatives were selected by the help of the Marketing Engineering for Excel (version 2.1.0) (Appendix 1.). Then respondents were asked to rank the bundles or the set of attributes from 1 to 16 depends on their preference (from the more preferred to the less preferred), then the data collected from the 155 respondents were converted to percentages from 0% to 100 %. After the entering of the converted data into the Marketing Engineering software for Excel, the Preference Partworths were estimated. In the conjoint analysis the part-worth utilities of individual attributes are calculated based on the selection or ranking of a defined set of combinations of attribute values. After this, profiles of the existing smart home products in the market were created and market share was predicted for different scenarios, using the First-Choice Rule.

A. Preference Part-Worth

In this research, all the 155 respondents ranked the combinations of attributes (bundles). Then this ranking was converted into percentages. Based on the ranking done, the conjoint analysis software (Marketing Engineering Software for Excel Version 2.1.0), calculates how each attributes contributes to the consumer's preference. The term used for the attribute level's contribution is "Part- worths utility".

By using excel as a tool the mean part-worth utility has been calculated for the 155 respondents for each attribute's level (TABLE 7). Therefore, each level's part-worths were investigated. With regard to the privacy and security, a smart product with a high privacy and security had taken the greater utility while a product without security and privacy had the lowest utility. A smart product with a low cost was more preferred with a higher utility, a smart product with a high cost is the less preferred. When it comes to analyze the utility of the reliability attribute, we find that the utility of the two levels moderately reliable and extremely reliable are so near, which shows that respondents goes more for extremely reliable smart home products, but if they face a smart product with a moderate reliability they would purchase it as well. The same case happened with the cost, the utility of low cost smart home products had approximately the same utility as moderate cost ones. The remaining utilities can be read from TABLE 7.

TABLE 7. MEAN OF RESPONDENTS' PREFERENCE PARTWORTH

Attributes	Levels	Utility
Privacy and Security	Impossible	8,187
	Moderate	15,897
	High	27,252
Reliability	Not At All Reliable	6,897
	Moderately Reliable	9,832
	Extremely Reliable	9,877
Usefulness	Not At All Useful	3,523
	Moderately Useful	11,690
	Extremely Useful	14,071
Interoperability	Not At All Interoperable	7,239
	Moderately Interoperable	8,000
	Extremely Interoperable	5,445
Cost	Low	9,555
	Moderate	9,206
	High	7,032

Respondents globally felt that the privacy and security is having the highest importance among attributes (33 per cent), then followed by usefulness (19 per cent), cost and reliability (17 per cent), and finally interoperability (14 per cent) (TABLE 8.). Privacy and security was approximately two times as important for consumers as cost and as reliability.

Privacy and security and usefulness accounted for more than 50 % of the importance that all respondents affected to the smart home products attributes. The interoperability of the smart home products was the attribute the least-valued.

TABLE 8. THE MEAN OF ATTRIBUTE IMPORTANCE

Attributes/Attribute Importance	Privacy and Security	Reliability	Usefulness	Interoperability	Cost
The Mean of Attribute Importance	33%	17%	19%	14%	17%

The privacy and security attribute utility demonstrates that respondents in this research were privacy and security mindful, obtaining a higher utility from a smart product with the highest privacy and security. They can be somehow judged as being a privacy and security sensitive, because they obtained a higher utility from the smart home products that have a high privacy and security, that are extremely useful and reliable but with a moderate interoperability and a low cost. Eventually as a result, consumers are expecting smart home products with first high privacy and security, products that are extremely useful, moderately to extremely reliable and with a low to moderate cost.

B. Existing profile products

In this research, we used some existing products in the market in order to run the analysis. These existing product profiles are picked from Smart Home Products market precisely as they are the top sellers. The levels affected to each attribute of these products have been taking into account approximately according to their technical characteristics mentioned in the website (www.smarthome.com).

Following are the nine existing profile products picked and used in order to run the market share simulation by using the respondent's partworths preference results (TABLE 9.):

TABLE 9. EXISTING PROFILE PRODUCTS

Attributes / Existing Product Profiles	Inseton Hub Central Controller	Amazon Echo Spot- Smart Alarm Clock	Inseton Smart Dimmer Switch
Privacy and Security	High	High	Impossible
Reliability	Moderately Reliable	Extremely Reliable	Extremely Reliable
Usefulness	Extremely Useful	Extremely Useful	Moderately Useful
Interoperability	Extremely Interoperable	Moderately Interoperable	Not At All Interoperable
Cost	Low	Moderate	Moderate
Attributes / Existing Product Profiles	LIFX- App Controlled Wi-Fi Smart LED Light	Inseton Remote Control Wall	Arlo Pro Wireless HD Security Camera
Privacy and Security	Impossible	Impossible	High
Reliability	Extremely Reliable	Moderately Reliable	Extremely Reliable
Usefulness	Moderately Useful	Extremely Useful	Extremely Useful
Interoperability	Extremely Interoperable	Not At All Interoperable	Extremely Interoperable
Cost	Low	Low	High
Attributes / Existing Product Profiles	Ring 88LP000CH000 Wi-Fi Video Doorbell Pro	ELK Two-Way Wireless Ready M1	NEST x Yale Lock (Satin Nickel) With Nest
Privacy and Security	High	High	High
Reliability	Extremely Reliable	Extremely Reliable	Extremely Reliable
Usefulness	Moderately Useful	Extremely Useful	Extremely Useful
Interoperability	Extremely Interoperable	Not At All Interoperable	Not At All Interoperable
Cost	Moderate	High	High

C. Market share simulations

The market share simulations have been done by using the partworths utilities for each consumer for the all of 155 consumers. The conjoint analysis findings were taken and utilized in order to simulate choices between nine existing

products (see TABLE 9). TABLE 10 resumes the predicted market share for a simulation with the nine existing product profiles.

Existing Product Profiles	Predicted Market Share
Inseton Hub Central Controller	30%
Amazon Echo Spot- Smart Alarm Clock	15%
Inseton Smart Dimmer Switch	7%
LIFX- App Controlled Wi-Fi Smart LED Light	5%
Inseton Remote Control Wall	7%
Arlo Pro Wireless HD Security Camera	4%
Ring 88LP000CH000 Wi-Fi Video Doorbell Pro	10%
ELK Two-Way Wireless Ready M1	10%
NEST x Yale Lock (Satin Nickel) With Nest	10%

In the market share simulations, the "Arlo Pro Wireless HD Security Camera" had only 4% of the market share, according to the respondents partworths preference this security camera has to work more on its cost and it can reduce its interoperability in order to improve that later. The "Inseton Hub Central Controller" had the largest market share with 30%, the hub central controller can reduce from its interoperability and improve its reliability in order to maintain its market share. After the Hub central controller comes the "Amazon Echo Spot- Smart Alarm Clock" with a market share of 15%, this only 15% is explained by the moderate cost of the smart alarm clock, the producers need to work more on cost in order to increase their market share. Then, come the "Ring 88LP000CH000 Wi-Fi Video Doorbell Pro", "ELK Two-Way Wireless Ready M1", and "NEST x Yale Lock (Satin Nickel) With Nest" in a same level with an equal market share of 10%, the three products are having high security and privacy and are extremely reliable which is so much expected and needed by consumers. However, when it comes to usefulness the Doorbell Pro has to improve this in order to survive in the market, otherwise, three of them need to work on their interoperability and costs to meet the consumers' expectations which are moderate interoperability with a low cost. The "Inseton Smart Dimmer Switch" and "Inseton Remote Control Wall" have equally a market share of 7%. This is due to their lack of privacy and security which considered -as mentioned in TABLE 9- as the most important attribute for a smart home product, also by the absence of the interoperability attribute in the product. Finally, for "LIFX- App Controlled Wi-Fi Smart LED Light", comes with a market share of 5%, this market share can be increased by adding the privacy and security feature to the product, the usefulness has to be increased as well and the interoperability can be reduced to be moderate, that way the cost may not be affected as well.

D. Appendix

APPENDIX 1. ATTRIBUTE LEVELS FOR A FULL-ROFILE, FRACTIONAL DESIGN CONJOINT ANALYSIS

Attributes / Bundles	Bundle 1	Bundle 2	Bundle 3	Bundle 4
Privacy and Security	Impossible	Impossible	Impossible	Impossible
Reliability	Not At All Reliable	Moderately Reliable	Extremely Reliable	Moderately Reliable
Usefulness	Not At All Useful	Moderately Useful	Extremely Useful	Moderately Useful
Interoperability	Not At All Interoperable	Extremely Interoperable	Moderately Interoperable	Moderately Interoperable
Cost	Low	Moderate	Moderate	High
Attributes / Bundles	Bundle 5	Bundle 6	Bundle 7	Bundle 8
Privacy and Security	Moderate	Moderate	Moderate	Moderate
Reliability	Not At All Reliable	Moderately Reliable	Extremely Reliable	Moderately Reliable

Usefulness	Moderately Useful	Not At All Useful	Moderately Useful	Extremely Useful
Interoperability	Moderately Interoperable	Moderately Interoperable	Extremely Interoperable	Not At All Interoperable
Cost	Moderate	High	Low	Moderate
Attributes / Bundles	Bundle 9	Bundle 10	Bundle 11	Bundle 12
Privacy and Security	High	High	High	High
Reliability	Not At All Reliable	Moderately Reliable	Extremely Reliable	Moderately Reliable
Usefulness	Extremely Useful	Moderately Useful	Not At All Useful	Moderately Useful
Interoperability	Extremely Interoperable	Not At All Interoperable	Moderately Interoperable	Moderately Interoperable
Cost	High	Moderate	Moderate	Low
Attributes / Bundles	Bundle 13	Bundle 14	Bundle 15	Bundle 16
Privacy and Security	Moderate	Moderate	Moderate	Moderate
Reliability	Not At All Reliable	Moderately Reliable	Extremely Reliable	Moderately Reliable
Usefulness	Moderately Useful	Extremely Useful	Moderately Useful	Not At All Useful
Interoperability	Moderately Interoperable	Moderately Interoperable	Not At All Interoperable	Extremely Interoperable
Cost	Moderate	Low	High	Moderate

3. CONCLUSION

Privacy and security and usefulness were preferred to be the most important attributes for the smart home products, comes then the cost and reliability, and finally the interoperability. The utility among attributes has a considerable variation. High privacy and security had received the highest utility, then the moderate privacy and security and. This shows that consumers of smart home products are privacy and security mindful. This is also noticed on respondents' usefulness preference for an extremely useful smart home product rather than smart home products with less usefulness. An extremely reliable smart home product had a higher utility than a moderately reliable or a none reliable smart home product, also at the same level of importance comes the cost. A low cost smart home product is more preferred by consumers with the highest utility, but a moderate cost can be also acceptable since there wasn't a considerable variation between the two levels. A moderately interoperable smart home product was more preferred by consumers, then comes a none interoperable product, which shows that interoperability is not taken a lot of attention by consumers. The product profile that has the highest possible utility for all the 155 respondents was a smart home product with a high privacy and security, extremely useful and reliable, moderately interoperable with a low cost. the profile that has got the least utility had only an extreme interoperability and a high cost with the absence of the other attributes. Producers who provide smart home products with this utility can use the part-worth analysis of every single attribute in order to find out how they can boost the consumer's utility from the smart home products. Smart home product companies should take into account these findings; they need to check with technicals in order to improve the privacy and security attribute of their products since it had taken the highest importance by respondents; they need to highlight the usefulness of the products while devising marketing, pricing or promotional campaigns that strived for rising the purchase of smart home products.

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