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# Factors Influencing Purchase of Smart Appliances in Smart Homes

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**Abstract**

Advances in information technology and communications with related computational power are providing a wide spectrum of systems forming the basis of smart home technologies. The appliances with the help of Internet of things (IoT) are used to support the health, safety, and independence of people in smart homes. This research examines the various factors which influence consumers purchase intention of smart appliances. A structural equation was formed using ADANCO modeling tool with the results gained from the consumer questionnaire designed to test the independent variables. Using this, hypotheses are defined and tested. Responses were received from a sample of 302 respondents geographically covering Asia Pacific, America, Australia and Europe. The research shows that all five factors have an impact on the purchase intention with interoperability having the strongest influence followed by privacy & control, technology, awareness and social factor. Therefore, the study implies that smart appliance manufacturers should focus more on the first two factors that are interoperability and privacy & control when communicating with customers which in turn would help them to decide on a purchase.

**Keywords:** smart appliances, smart home technologies, interoperability, internet of things.

## I. INTRODUCTION

Smart Appliances are specialized consumer appliances that can be interconnected over smartphone, tablet or computer in smart homes. Smart appliances help us to save energy, can be controlled when away from home, alerts the user in case of emergency, interacts with nearby appliances and co-exist. In other words, it can be said that smart appliances are the future of every household. Smart homes aim to provide enhanced convenience and comfort, energy efficiency, security, and surveillance. It is forecasted by market experts that majority of homes will be equipped with smart appliances in the near future.

As per new market research report "smart appliances market by smart home appliances (washer, dryer, air conditioner, vacuum cleaner), smart kitchen appliances

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(refrigerator, dishwasher, freezer), technology (wi-fi, NFC, bluetooth), end user, and region - global forecast to 2020", the smart appliances market is estimated to reach USD 37.2 Billion by 2020.

As per above research report, the smart appliances market is expected to grow at a CAGR of 15.4% between 2015 and 2020. With the help of smart appliances, consumers can shift their energy consumption to off-peak periods and can optimize their energy use. Consumers nowadays prefer energy-efficient smart appliances due to rising energy prices. Increased government regulations regarding energy consumption are also one of the factors driving the growth of the smart appliances market.

A review of the literature shows that some studies have been conducted on the smart/consumer appliances and the technical aspect of connecting various appliances effectively over the network.

However, very limited studies have been done on factors influencing the purchase of smart appliances in smart homes. Hence a need arises to conduct an in-depth study on "factors influencing the purchase of smart appliances in smart homes."

Using the literature review, the scope of the project can be extended further to the following areas:

1. Technology (Mahmood et al., 2013; Kumar & Lee, 2014; and Al-Ali & Aburukba, 2015).
2. Privacy & control (Notra et al., 2014; Yoshigoe et al., 2015; and Vanus et al., 2015).
3. Awareness (Zhao, 2000; Bailey, 2005).
4. Social factors (Disterer, 2001; Jones & Boyd, 2011).
5. Interoperability (Den Hartog et al., 2015; Daniele et al., 2016).

More research has to go into the areas mentioned above along with factors influencing the purchase of smart appliances in smart homes. This research aims to deliver key insights that would be considered by consumers when purchasing a smart appliance.

## II. REVIEW OF LITERATURE AND RESEARCH STRUCTURE

The existing literature finds out the driving forces for smart appliances in smart homes, which are affected by factors such as technology, privacy & control, awareness, social factors, and interoperability.

### 2.1. Technology

Technology plays a significant role in today's era, and people's life is gradually changing with the advent of smart appliances in smart homes. The major parameters influencing technology are smart living (Kumar & Lee, 2014), smart phone (Kumar & Lee, 2014), energy (Mahmood et al., 2013), smart grid (Al-Ali & Aburukba, 2015).

**$H_1$:** technology has a positive impact on the purchase of smart appliances in smart homes.

#### 2.1.1. Smart Living

Smart Living is a pattern incorporating progressions that give individuals the chance to benefit from new ways for a living. It includes unique and innovative solutions making life more proficient, more controllable, temperate, profitable, coordinated and manageable. This is a pattern that covers every part of everyday life, from habitations and work environments to the way in which individuals are transported inside urban communities. In a home scenario, connection with the smart living system can be made from the designed app either by bluetooth or internet connection (Kumar & Lee, 2014). Additionally, it also includes home security and surveillance system.

**2.1.2. Smart Phone**

The consistent development of smart phones in its acknowledgment and usefulness has prompted an expansion in the interest for cutting-edge versatile universal applications in individuals' day to day lives. Advanced mobile phones are something other than telephones in today's life having a wide scope of utilizations, for example, education, health services and amusement. Different smart home frameworks have been proposed where the control is by a) bluetooth, b) internet, c) SMS, d) voice controlled smart home and e) microcontroller based voice activation (Kumar & Lee, 2014). With the proposed system, light sensors, temperature, gas, motion detection and alarm sensors can be controlled effectively.

**2.1.3. Energy**

In smart homes (Mahmood et al., 2013), the appliances or devices consume energy in efficiently and operate digitally. Smart home devices can observe activities inside the home and utilizes technology that empowers the devices, for instance, to turn on and off automatically resulting in energy saving. The paper reports that with smart appliances, energy can be saved tremendously as compared to manual appliances by developing an energy management system and using technologies like ZigBee over bluetooth or wi-fi.

**2.1.4. Smart Grid**

An integration of traditional electric power grid with information technologies & telecommunications would be termed as Smart Grid. Combined with the internet of things context, (Al-Ali & Aburukba, 2015) a conceptual model has been proposed wherein the integration of smart home appliances was done, and each appliance was considered a single unique object and a unique IP address was given. With this, the appliances can be made to connect to the internet, and their status can be transmitted, or control command can be received. This will have a significant impact on the energy management of smart appliances.

**2.2. Privacy and Control**

One of the biggest hurdles when it comes to smart appliances would be privacy. With consumer appliances connected over the internet, privacy may be put at risk, and potentially user may lose control of their smart appliances with hackers monitoring user activities. The major parameters influencing privacy & control are alarm functionality (Notra et al., 2014), surveillance (Notra et al., 2014), voice recognition (Vanus et al., 2015), emergency contact (Wang et al., 2014).

**$H_2$:** privacy & control have positive impacts on the purchase of smart appliances in smart homes.

**2.2.1. Alarm Functionality**

At adverse times, alarm functionality would be absolutely necessary to keep people informed. With appliances such as Nest Smoke – Alarm, whereby the device monitors if the user is in room or not and also if the lights are turned on or not. It alarms the user in terms of verbal warnings, beeps, LED lights & text alerts in mobile apps. This could also raise a privacy concern among users who may feel they might be monitored by hackers. This has been (Notra et al., 2014) tested and found that Nest cannot be contacted by any external server and all traffic is only initiated by nest. In case of emergency, Nest send messages to external server and the user receives notification. However, this has privacy concerns since large amount of log data is captured apart from alarm functionality and this could pose security risk to users. A possible solution as stated in the paper (Notra et al., 2014) would be to block access to

log server without disturbing the alarm functionality. This rule successfully blocked the server but gave way for fire alarm notifications for users.

**2.2.2. Surveillance**

Cameras and microphones incorporated with surveillance hardware can be utilized by programmers to keep an eye on family activities. There are instances of programmers breaking into Internet-connected baby monitors to talk obscenities and meddle with family. A few IoT applications are firmly connected to some infrastructures such as water/power distribution and its surveillance. Different applications handle delicate data about individuals, for example, their area and movements, or, on the other hand, their wellbeing and purchasing behavior. A smart home gives the client a chance to control the majority of his/her gadgets with ease. Sadly, it likewise gives a stage to the programmers to hack into the home system, and remotely control different automated types of equipment. (Notra et al., 2014).

**2.2.3. Voice Recognition**

To be able to control the operating and technical functions of smart appliances by voice would be beneficial to many as it would enable them to go hands-free. In particular, the seniors would be benefitted the most in smart home care. (Vanus et al., 2015) The paper focussed on implementing a comfortable voice control which will be recognised with ease. One of the major roadblocks addressed was the ability to resolve voice recognition with additive noises in any given environment.

**2.2.4. Emergency Contact**

A unique advantage of Smart appliances would be the ability to contact regarding the emergency. The emergency could be due to a fire alarm, smoke alarm, theft, accidental fall. For the elderly, accidental fall could be very dangerous and a fall detection system would be preferred to improve the quality of life. To address this particular issue, (Wang et al., 2014) an enhanced fall detection system was devised with the use of wearables, vision and ambient based methods and the results achieved a higher accuracy.

**2.3. Awareness**

The market for smart appliances is bound to be successful only if the end consumers are aware of the features and benefits that the smart appliances could offer. Awareness of good influences the purchase behavior of a consumer. On the other hand, it is the job of consumer appliance manufacturer to raise enough awareness among the public about their product. The major parameters influencing awareness are an advertisement (Zhao, 2000), product review (Bailey, 2005), word of mouth (Bailey, 2005), price & quality (Zhao, 2000).

**$H_3$:** awareness has a positive impact on the purchase of smart appliances in smart homes.

**2.3.1. Advertisement**

Advertisements play a major role in influencing consumers. A firm can advertise only to raise awareness about its product or to signal its quality or can do both. The article (Zhao, 2000) clearly defines the type of advertising to be focussed. If a high-quality firm is introducing its product, it can increase its price thereby increasing its profit. However, the same can be replicated by a low-quality firm whose product quality is unknown, and since the product quality is unknown, they can set the price at a much higher level. This can be tackled by the high-quality firm by reducing advertising spending and let the quality of the product speak for itself. Ultimately, advertising

makes a consumer aware of the smart appliance product, and it helps them to decide on which product to opt for.

**2.3.2. Product Review**

With the advent of the Internet, research shows that consumers make use of internet a lot to browse on additional information and their internet research would be a decisive factor in purchasing a product. (Bailey, 2005) According to the research, consumers browsed product review websites and made use of the information available at these websites in making their final decision.

**2.3.3. Word of Mouth**

Research has shown that word of mouth communication received extensive attention from customers from both online and offline platform. With the introduction of smart appliances, it is necessary to keep positive feedback on the product. Since word of mouth can be both positive and negative, and a negative one would be deteriorating to the brand image. Word of mouth would influence the consumer attitude, purchase behavior, decision making. Word of mouth could be from online media or offline media like friends, neighbors, family members, colleagues and many more (Bailey, 2005).

**2.3.4. Price and Quality**

While some may assume that if a firm sheds out a lot of money in advertising without being informative, it means that the product is of high quality. However, according to Zhao (2000), simple spending money is not a signal of quality. When information about a product is not readily available, even if a product is of high quality, it is recommended to spend less on advertising since increased advertising could result in mimicry of the product. A firm with a high-quality product should make the price speak for the quality and initially conduct an advertising campaign to gather info on the market feedback.

**2.4. Understanding Social Factors**

Social Factors are barriers to passages which are made by the culture of people. It is basically the peoples' behavior towards newcomers or others in general. It is important to understand how social factors could vary depending on expertise, location, culture. The major parameters influencing social factors are a cultural issue (Balta-Ozkan et al., 2013), adaptation (Jones & Boyd, 2011), language (Truong et al., 2015), personalization (Disterer, 2001).

**$H_4$:** social factors have a positive impact on the purchase of smart appliances in smart homes.

**2.4.1. Cultural Issue**

The article by Balta-Ozkan et al. (2013) helps to understand the various cultural issue in adoption to the smart home. It is also important to understand the need, demands, and requirements of the locals. Care should be taken to ensure that the technology and services integrate into the local design and appeals to the end user. The local consumers should not feel out of control, and the users should not have to develop technical knowledge to use the smart appliance. While many positive factors of smart appliances like automatic lighting, energy saving, security systems, air quality add to the benefit, there are some concerns when it comes to controlling, reliability data security. Smart home manufacturers should take action to adopt to the cultural flavor of the local when entering the market.

### 2.4.2. Adaptation

Jones and Boyd (2011), explores how cognitive, normative and institutional determinants may influence adaptation at the local community. Adaptation is the process which people use to reduce adverse changes. In case of a consumer product, the smart appliance should be able to adapt to local flavor and the local community should not feel alienated with the equipment. Appliance manufacturers should keep in mind that people might show cognitive behavior (reluctance to accept outside product), normative behavior (persistence with the traditional form) (Jones & Boyd, 2011).

### 2.4.3. Language

Language acts as both enabler and a barrier. Truong et al. (2015), suggests that in today's diverse world, the dominance of English is visible. But, people whose native languages are not English face difficulty. Thus, to enter countries in Asia, Africa, Latin America, translation into the local language is preferable. Given this, smart appliances should have the ability to view in multiple local languages as this will enhance the user confidence in their product.

### 2.4.4. Personalization

With personalization, the individual is an expert and is cared for. This helps the individuals to keep control over the entire cycle (Disterer, 2001). Regarding smart appliances, personalization plays a huge role. This includes choosing colors of appliances, storage of cooking features in the oven to give the more personalized feel; it will be a crucial factor in any appliance. Furthermore, it is also possible to reduce peak electricity consumption based on personalized priority.

## 2.5. Interoperability

It is vital for appliances to work with each other for providing a quality lifestyle to the consumers. One of the difficulties based on interoperability is the availability of different data models, protocols, and specifications that are not interoperable. The major parameters influencing interoperability are standardization (Daniele et al., 2016), internet of things (Li & Yu, 2011), collaboration among manufacturers (Daniele et al., 2016), Network Connectivity (Den Hartog et al., 2015).

**$H_5$:** interoperability has a positive impact on purchase of smart appliances in smart homes.

### 2.5.1. Standardization

To overcome the fragmentation caused by different data models, it is necessary to have single solution that could connect all appliances. Usage of technologies like SAREF4EE, (Daniele et al., 2016) which enables interconnection of different data models in the smart home environment. It provides a common domain to map different mechanisms to one another. It enables interoperability between smart appliances produced by different manufacturers.

### 2.5.2. Internet of Things

IoT connects all appliances and the internet via sensing devices like infrared, GPS, laser scanner, RFID for control. IoT connected smart home comprises of family datils pertaining to medical history, purchasing pattern, customized preferences, security, entertainment, shopping (Li & Yu, 2011). IoT brings next era of IT innovations and can change our life and occupation to a more insightful one. The examination and use of part advances and the new application method of IoT, for example, sea computing can encourage the IoT to wider fields. Smart home, intelligent residential district and more different applications will show up in future.

### 2.5.3. Collaboration Among Manufacturers

With Interoperability being a decisive factor in smart homes, it is necessary for different manufacturers of smart appliances to collaborate for interconnecting their data. With SAREF created in collaboration with Energy@HOME industry & EEBus, smart home appliance manufacturer that support the above can easily communicate with each other using any energy management system at home or in the cloud (Daniele et al., 2016).

### 2.5.4. Network Connectivity

Nowadays appliances don't operate separately. With connected to network, they can plan for the whole cycle of energy consumption, production and managing systems. Therefore, with the right system of devices and sensors, the appliances can be connected to a network and can be configured to manage and control for energy saving measures (Daniele et al., 2016).

## 2.6. Theory of Consumer Buying (Purchase Intention)

Every product has certain attributes which form the basic elements of marketing mix. Groeneveld (1964) talks about a framework which can be conceptualized and used for practical purposes. This approach places the products on a spectrum of consumer buying intent by measuring various product characteristics. The article states about the need for a conceptual approach to understand the purchase intention. In line with this, a research framework has been framed and the variables independent variables are plotted.

**Table 1**
**Independent Variables for the Research Framework**

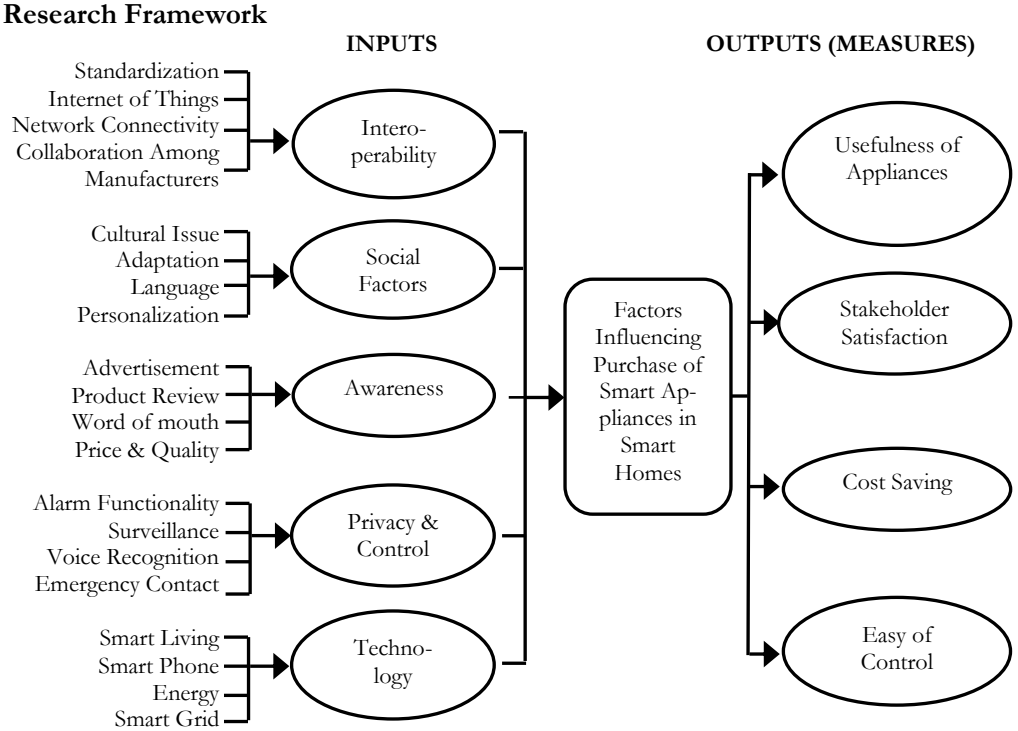
| S No. | Indicators | Literature Reference | Variables (Independent) |
|---|---|---|---|
| 1 | Smart Living | Kumar & Lee, 2014 | **Technology** |
| 2 | Smart Phone | Kumar & Lee, 2014 | |
| 3 | Energy | Mahmood et al., 2013 | |
| 4 | Smart Grid | Al-Ali & Aburukba, 2015 | |
| 5 | Alarm Functionality | Notra et al., 2014 | **Privacy & Control** |
| 6 | Surveillance | Notra et al., 2014 | |
| 7 | Voice Recognition | Vanus et al., 2015 | |
| 8 | Emergency Contact | Wang et al., 2014 | |
| 9 | Advertisements | Zhao, 2000 | **Awareness** |
| 10 | Product Review | Bailey, 2005 | |
| 11 | Word of Mouth | Bailey, 2005 | |
| 12 | Price & Quality | Zhao, 2000 | |
| 13 | Cultural Issue | Balta-Ozkan et al., 2013 | **Social factors** |
| 14 | Adaptation | Jones & Boyd, 2011 | |
| 15 | Language | Truong et al., 2015 | |
| 16 | Personalization | Disterer, 2001 | |
| 17 | Standardization | Daniele et al., 2016 | **Interoperability** |
| 18 | Internet of Things | Li & Yu, 2011 | |
| 19 | Collaboration Among Manufacturers | Daniele et al., 2016 | |
| 20 | Network Connectivity | Daniele et al., 2016 | |

## III. RESEARCH METHODOLOGY

The basis of the research was provided by information from literature review which held in formulating the secondary data, surveys, questionnaires and primary data. The scope for future research was identified by analyzing secondary data. This explains the factors influencing the purchase of smart appliances in smart homes. Using a survey questionnaire, the primary data was collected from a sample population consisting of potential and existing users of smart appliances from diverse background and varied income range across geographies. The dependent & independent variables were identified and their relationship in represented as below in Figure 6.

The collected data had been tested for its reliability and validity in section 5. Based on the analytical output of ADANCO software, all the five hypotheses were tested and shown the results in "Research Finding" section. The authors had explained in details the contribution of each measurable dimension on its respective constructs in section 6 and 7, and then Implications of factors influencing the purchase of smart appliances in smart homes, limitations, and conclusion for study are discussed in 8, 9 and 10th sections.

**Figure 1**
**Research Framework**




## IV. DATA COLLECTION AND ANALYSIS

### 4.1. Data Collection and Cleaning

The research gaps from reviewing the literature were covered in the questions developed for the research. Online portals like email, facebook, Linkedin and Whatsapp was used to circulate the questionnaire. The respondents were both existing and potential users of smart appliances. Before sending out the final questionnaire, a sample survey was taken, and some questions were modified based on the results. A Likert scale has been employed. The ranges are from strongly disagree (1) to strongly agree (5)

to record the responses. The demographics of the respondents were classified based on three industry sectors namely manufacturing, trading, and services.

Data has been collected from 328 respondents for 29 fields as per above methodology. As the data size is small, we have identified missing fields for 17 respondents and outliers (unusual observations) for nine respondents. Total missing and outliers 26 (=17+9) respondents data have been deleted, rest 302 respondent data treated as cleaned data used for analysis.

The descriptive statistical analysis of cleaned data has been presented in Annexure 1 for the reference.

**Table 2**
**Demographics of the Respondents (n=302) Concerning Industry Sector, Users and Region and Income Range for Both Genders**

| Item | Measure | Frequency | Percentage |
|---|---|---|---|
| Industry | Manufacturing | 81 | 27% |
| | Services | 193 | 64% |
| | Trading | 28 | 9% |
| Users | Current | 130 | 43% |
| | Potential | 172 | 57% |
| Region | Asia | 265 | 88% |
| | Europe | 13 | 4% |
| | America | 14 | 5% |
| | Australia | 10 | 3% |
| Income Range (in US Dollars) | <30,000 USD | 202 | 67% |
| | 30,000 – 100,000 USD | 77 | 25% |
| | >100,000 USD | 23 | 8% |

### 4.2. Data Analysis

The primary data was obtained from the consumer questionnaire, and the data was exported to an excel file. The data has been cleaned and ensured it is free of missing data, outliers, multicollinearity. Also tested for group differences concerning industry type, user type, region and income range, through ANOVA and found the p-value for each group is greater than 0.1 for all the four groups and concluded that there are no group differences significantly. Hence the resulted data were analyzed using ADANCO software by considering only one model, a structural equation modeling tool to postulate the hypothesis and construct the research framework. The composite modeling approach is used by ADANCO to test hypothesis utilizing the benefit of not imposing normality on data. The analysis was completed in two phases: In the first phase, the model was estimated. Once the estimation was done, in the second phase reliability and validity were measured. This helped to finalize the optimum fit model by adopting path analysis and estimating the model parameters.

### 4.3. Reliability

Alpha Cronbach's was used to determine the reliability of the model. The model was deemed to be reliable when the value is greater than 0.6. Jöreskog's Rho was used to measure the homogeneity and integrity of the model according to the composite reliability.

The constructs and its results are as follows.

**Table 3**
**Reliability of All Constructs**

| Construct | $R^2$ | Jöreskog's Rho ($\varrho_c$) | Cronbach's Alpha ($\alpha$) | Average Variance Extracted (AVE) |
|---|---|---|---|---|
| Factors Influencing Purchase of Smart Appliances in Smart Homes | 0.650 | 0.8446 | 0.7544 | 0.5765 |
| Technology | | 0.8509 | 0.7660 | 0.5882 |
| Privacy & Control | | 0.8037 | 0.6744 | 0.5077 |
| Awareness | | 0.8381 | 0.7599 | 0.5646 |
| Social Factors | | 0.8310 | 0.7423 | 0.5532 |
| Interoperability | | 0.8336 | 0.7341 | 0.5569 |

### 4.4. Convergent Validity

Indicator variables are measured by convergent validity which uses scores of conformities to scrutinize construct validity. The threshold accepted AVE value, ought to be equal or above 0.5. The least AVE value is 0.5077 obtained from the table. This fulfills the model measurement requirements. In-addition the researcher observed loadings and cross loading found that the items of a construct are highly loaded on its parent construct with minimum values of 0.732 (technology), 0.639 (privacy & control), 0.717 (awareness), 0.657 (social factors), and 0.68 (interoperability) and very low loading i.e. less than 0.5 of items on other than their parent construct hence it is concluded that convergent validity is very high.

**Table 4**
**Convergent Validity**

| Construct | Average Variance Extracted (AVE) |
|---|---|
| Factors Influencing Purchase of Smart Appliances in Smart Homes | 0.5765 |
| Technology | 0.5882 |
| Privacy & Control | 0.5077 |
| Awareness | 0.5646 |
| Social Factors | 0.5532 |
| Interoperability | 0.5569 |

### 4.5. Discriminant Validity

Discriminant validity has been proved by comparing squire of the correlation coefficient of constructs' matrix with AVE at diagonal and observed that each squired correlation is less than AVE hence discriminant validity is proved.

Insert Table 5 and Table 6 here.

Five hypotheses were postulated, and their reliability was verified against the verified t-values of the independent variables against the dependent variables. The results are as below.

**Table 5**
**Discriminant Validity**

| Construct | Factors Influencing Purchase of Smart Appliances in Smart Homes | Technology | Privacy & Control | Awareness | Social Factors | Interoperability |
|---|---|---|---|---|---|---|
| Factors Influencing Purchase of Smart Appliances in Smart Homes | 0.5765 | | | | | |
| Technology | 0.3519 | 0.5882 | | | | |
| Privacy & Control | 0.4123 | 0.2647 | 0.5077 | | | |
| Awareness | 0.0870 | 0.0729 | 0.0382 | 0.5646 | | |
| Social factors | 0.0717 | 0.0123 | 0.0646 | 0.0233 | 0.5532 | |
| Interoperability | 0.5589 | 0.3603 | 0.3570 | 0.0410 | 0.0561 | 0.5569 |

The diagonal values show the squared relations of the average variance extracted.

**Table 6**
**Significance Levels**

| | Significance | t-value |
|---|---|---|
| Significance Level | p<0.1 | 1.65 |
| | p<0.05 | 1.96 |
| | p<0.01 | 2.59 |

Insert Table 7 here

## V. RESEARCH FINDINGS

The path coefficient for all the identified hypothesis is significantly strong, and therefore these can be accepted.

Structural Equation Modelling (SEM), a statistical tool is employed between the variables to test the hypothesis. To test the model and the relationship between all measured variables, Path Analysis is used in addition to SEM. Both being linear statistical models, the validity is met with the right assumptions. Normal Distribution is followed by Regression. The path analysis takes a multivariate normality. The primary difference between path analysis and regression lies in the variables in path analysis are both independent & dependent. On the contrary, for regression, the variables would be either independent or dependent. With SEM, one would be able to specify error or unexplained variance whereas, in regression, measurements are assumed without error (Mahmood et al., 2013; Kumar & Lee, 2014; and Al-Ali & Aburukba, 2015).

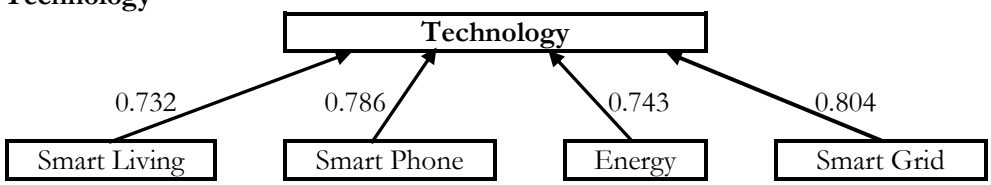
It is evident that the path coefficients of individual constructs play a significant role in understanding the reliability of the SEM model.

**Table 7**
**Results of the Hypothesis Testing Percentile Bootstrap Quantiles**

| Hypo-thesis | Effect | Original Coef. | Mean Value | Standard Error | t-value | p-value (2-sided) | p-value (1-sided) | 0.5% | 2.5% | 97.5% | 99.5% | Sup-ported |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $H_1$ | TE → Purchase of Smart Appliances | .1453 | .1508 | .0640 | 2.2696 | .0233 | .0116 | -.0126 | .0248 | .2788 | .3111 | Yes |
| $H_2$ | PC → Purchase of Smart Appliances | .2464 | .2478 | .0641 | 3.8458 | .0001 | .0001 | .0829 | .1224 | .3742 | .4060 | Yes |
| $H_3$ | LA → Purchase of Smart Appliances | .1015 | .1052 | .0349 | 2.9076 | .0037 | .0018 | .0158 | .0372 | .1736 | .1976 | Yes |
| $H_4$ | SB → Purchase of Smart Appliances | .0602 | .0648 | .0344 | 1.7519 | .0798 | .0399 | -.0235 | -.001 | .1326 | .1547 | Yes |
| $H_5$ | IO → Purchase of Smart Appliances | .4783 | .4700 | .0669 | 7.1528 | .0000 | .0000 | .2887 | .3335 | .5934 | .6321 | Yes |

The individual contributors to each hypothesis would be as follows.

**Figure 2**
**Technology**

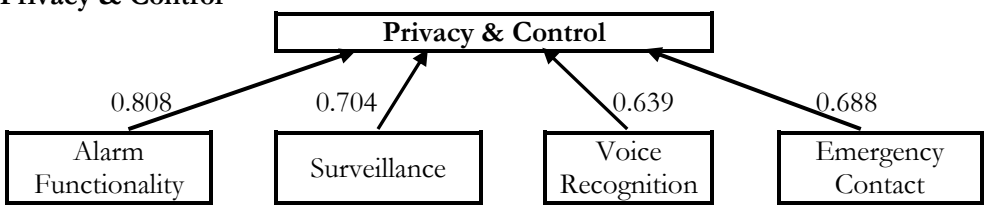



In the above Structured Equation Model, the variable Smart Grid (0.804) has the path coefficient which is above 0.8 thereby indicating the strong effect on the independent variable. Whereas, the path coefficient for a smart living (0.732), smart phones (0.786), energy (0.743) ranges between 0.5 & 0.8 signifying a moderate effect on the independent variable – technology.

**$H_1$:** technology has a positive impact on the purchase of smart appliances in smart homes.

The first hypothesis, $H_1$, examines the factor – technology on the factors influencing the purchase of smart appliances in smart homes. The variable technology seems to have a significant effect (t-value= 2.2696, CI>95%); therefore, $H_1$ ($\beta$= 0.1453, $p<0.05$) stands accepted. This indicates that technology has a significant impact on factors which influence the purchase of smart appliances in smart homes.

**Figure 3**
**Privacy & Control**



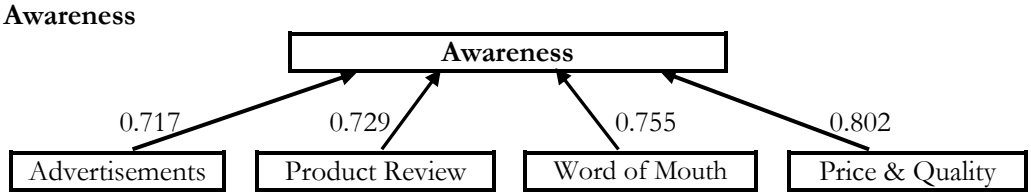

In the above SEM model, the path coefficient for individual construct – Alarm Functionality (0.808) – has a strong influence on the independent variable, whereas surveillance (0.704), voice recognition (0.639), emergency contact (0.688) have moderate effect on the independent variable – privacy & control (Notra et al., 2014; Vanus et al., 2015; and Yoshigoe et al., 2015)

**$H_2$:** privacy & control have positive impacts on the purchase of smart appliances in smart homes.

The second hypothesis, $H_2$, highlights the effect of privacy & control on the factors which influence the purchase of smart appliances in smart homes. The effect of privacy & control shows a strong influence (t-value= 3.8458, CI>99%). Hence, $H_2$ ($\beta$= 0.2464, $p<0.01$) stands accepted. This indicates that privacy & control is very significant of the factors which influence the purchase of smart appliances in smart homes.

**$H_3$:** awareness has a positive impact on the purchase of smart appliances in smart homes.

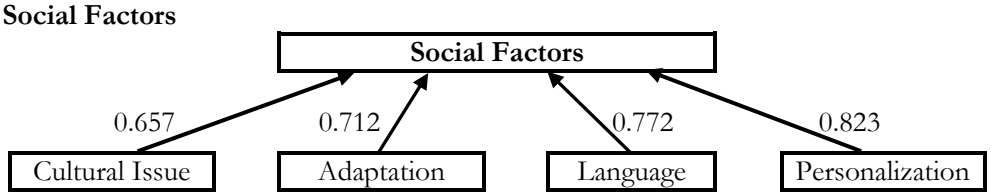
**Figure 4**
**Awareness**



In the above SEM model, the path coefficient for individual construct – Price & Quality (0.802) has a strong influence on the independent variable while other constructs like advertisement (0.717), product review (0.729), word of mouth (0.755) have moderate effect on the independent variable – awareness (Zhao, 2000).

The third hypothesis, $H_3$, tested the effects of Awareness on the factors which influence the purchase of smart appliances in smart homes. The effect of awareness is significant (t-value= 2.9076, CI>98%). Thus, $H_3$ ($\beta$= 0.1015, $p<0.02$) is accepted. This indicates that Awareness has a very significant impact on factors which influence the purchase of smart appliances in smart homes.

**Figure 5**
**Social Factors**

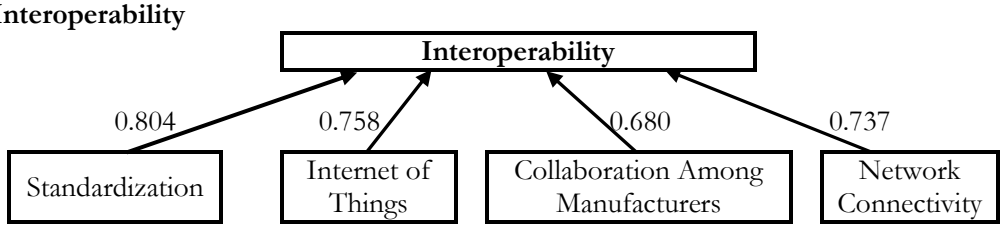



In this model, the path coefficient for the individual construct personalization (0.823) is greater than 0.8 signifying that it has a strong impact on the independent variable. On the other hand, constructs like the cultural issue (0.657), adaptation (0.712), language (0.772) have a path coefficient in the range of 0.5 to 0.8 which implies that there is a moderate impact on the measured variable – social factors (Disterer, 2001; Jones & Boyd, 2011).

**$H_4$:** social factors have a positive impact on the purchase of smart appliances in smart homes.

The fourth hypothesis, $H_4$, tested the effects of Social factors on the factors which influence the purchase of smart appliances in smart homes. The effect of social factors is the least significant (t-value= 1.7519, CI>90%). Therefore, $H_4$ ($\beta$= 0.0602, $p<0.1$) stands accepted. This indicates that social factors have the least significant impact on factors which influence the purchase of smart appliances in smart homes.

**Figure 6**
**Interoperability**




The influence of constructs on SEM affects the independent variables which in turn impacts the dependent variable.

In this model, the path coefficient for Standardization (0.804) is above 0.8 which again signifies a strong influence on the independent variable. The constructs internet of things (0.758), Collaboration among manufacturers (0.680) and network connectivity (0.737) ranges between 0.5 and 0.8, which implies that these have a moderate effect on the independent variable – interoperability (Den Hartog et al., 2015; Daniele et al., 2016).

**$H_5$**: interoperability has a positive impact on the purchase of smart appliances in smart homes.

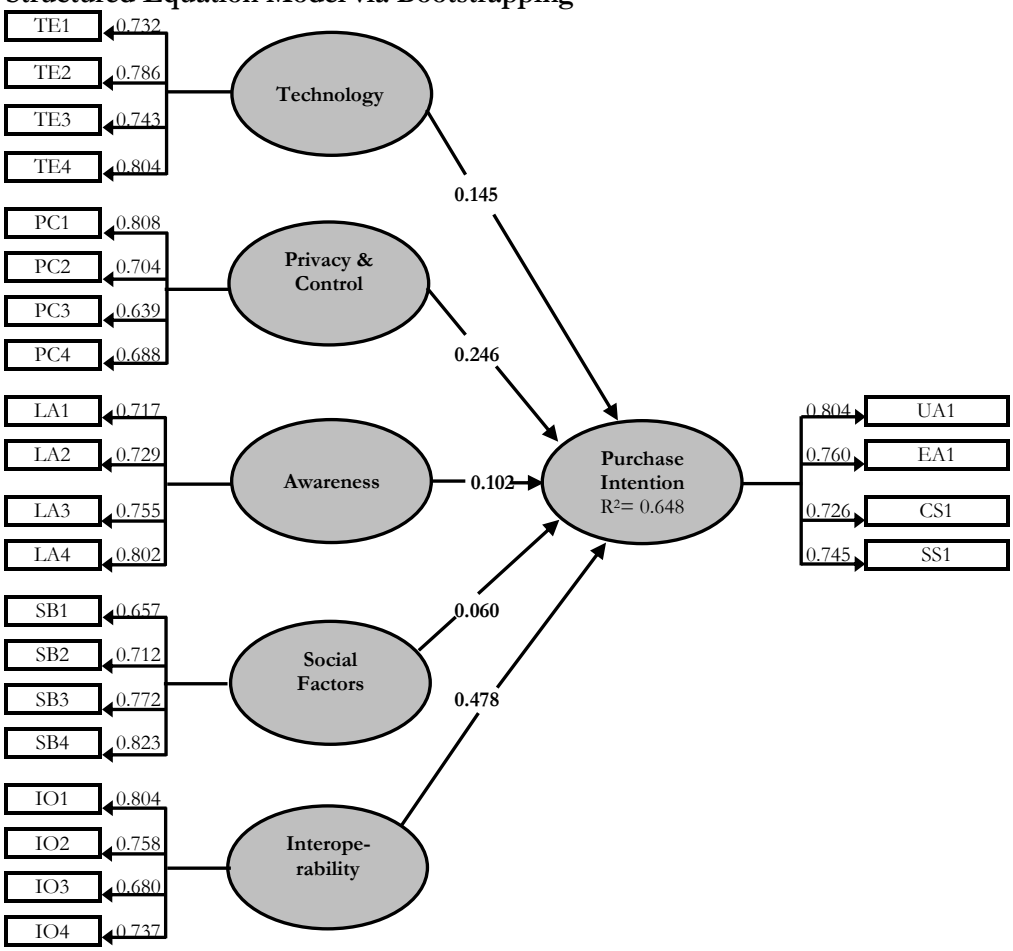
The fifth hypothesis, $H_5$, tested the effects of interoperability on the factors which influence the purchase of smart appliances in smart homes. The effect of

interoperability has a strong influence (t-value= 7.1528, CI>99%). Hence, $H_5$ (β= 0.4783, p<0.01) stands accepted. This indicates that interoperability has the most significant impact on factors which influence the purchase of smart appliances in smart homes.

Graphical Representation of The Model.

**Figure 7**

**Structured Equation Model via Bootstrapping**




## VI. CONTRIBUTIONS

### 6.1. Factors Influencing Purchase of Smart Appliances in Smart Homes

It is very crucial to understand the numerous factors that a consumer might need to decide on the purchase of smart appliances in a smart home. However, deciding on the brand, investing on the smart appliances, how better can it be used by the household, how much long-term saving will it be able to incur and finally the how easy will it be able to learn to control the appliances would ultimately determine the consumer's purchase decision.

#### 6.1.1. Usefulness of Appliances

Previous studies have shown that two features further emerge which is central to the smart home technology. The features show tremendous potential to evolve which is ideal for smart home appliances (Balta-Ozkan et al., 2013). This research helps in

further understanding the importance of usefulness of smart appliances and with interoperability playing a major role for the purchase factor further reinstates the above literature reading.

**6.1.2. Stakeholder Satisfaction**

The research has been conducted with both potential smart appliance users and current users. The literature review stated that privacy being a key issue in smart home development and how smart home developers must explicitly convey the benefit from smart home development. (Wilson et al., 2015). The research findings further confirmed on the importance of privacy & control is a key factor in purchase intention as well as for existing smart home users and it agrees with the above said literature finding.

**6.1.3. Cost Saving**

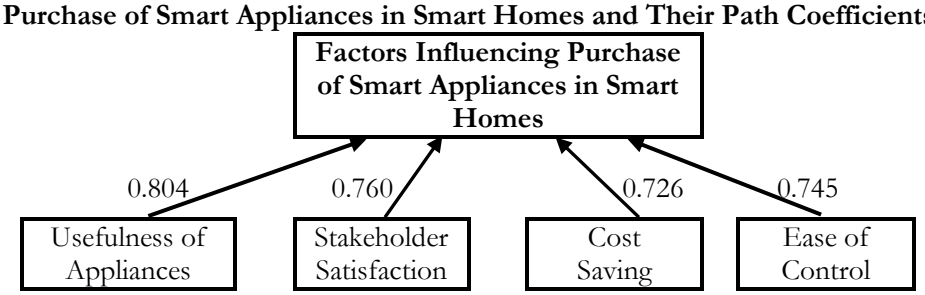
According to the literature review, users are assumed to have a stable set of service demands such as comfort, safety, security and cost (Hargreaves et al., 2013). The developers should aim at maximizing comfort and minimizing cost. This relates further to the technology factor and personalization factor which are in line with the above literature findings.

**6.1.4. Ease of Control**

No matter the technology developed and adopted in a smart appliance, the user control should be handled smoothly. The control can be a combination of both automation and user control (manually) or could be separate. There needs to be a co-presence among users for control of smart home technologies (Hargreaves et al., 2013). This complies with our research finding wherein personalization for individual users and technology for easier control seems to be crucial factors in taking a purchase decision.

**Figure 8**

**Purchase of Smart Appliances in Smart Homes and Their Path Coefficients**




In this Structured Equation Model, the path coefficient for all the constructs represent measures of the factors which influence the purchase of smart appliances in smart homes. The individual construct usefulness of appliances (0.804) is greater than 0.8, signifying that it has a much stronger impact than other variables. The path coefficient for the individual constructs Stakeholder satisfaction (0.760), cost saving (0.726), ease of control (0.745) range between 0.5 and 0.8, implying that there is a moderate impact on the measured variables – factor influencing purchase of smart appliances in smart homes

**6.1.5. Consumer Behavior Model (Purchase Intention of Smart Appliances)**

Thus, from the above results, it is evident that all four variables lead to purchase intentions. Similar to what was stated in the article by Groeneveld (1964), the survey shows the importance of various factors which would influence smart appliance purchase intention. The output variables usefulness of appliances, stakeholder

satisfaction, cost saving, ease of control. These variables place the spectrum of consumer purchase intention through a variety of factors.

By the end of this research paper, one should be able to understand the factors that would influence a consumer to purchase smart appliance in smart home and understand.

a) The usefulness of smart appliances in smart homes.
b) Stakeholder satisfaction.
c) Cost savings involved.
d) Ease of control.

## VII. IMPLICATIONS OF FACTORS INFLUENCING PURCHASE OF SMART APPLIANCES IN SMART HOMES

The objective of this research is to find out the impacts of the five factors namely technology, privacy & control, awareness, social factors and interoperability which would typically influence the purchase of smart appliances. Would customers buy just like that similar to a regular appliance? The answer is no; the customers need special awareness on the usage of smart appliances and indicate to them about the long-term benefit. The research shows that all five factors have an impact on the purchase intention with interoperability (β= 0.4783, t-value= 7.1528, p= 0.0000) having the strongest influence followed by privacy & control (β= 0.2462, t-value= 3.8458, p= 0.0001), technology (β= 0.1453, t-value= 2.2696, p= 0.0233), awareness (β= 0.1015, t-value= 2.9076, p= 0.0037), social factor (β= 0.0602, t-value= 1.7519, p= 0.0399). Therefore smart appliance manufacturers should focus more on the first two factors that are interoperability and privacy & control when communicating with customers which in turn would help them to decide on purchase. Most of the studies have proved the similar hypothesis but not mentioned the relative importance of five factors hence the study is unique. The results are highly specific to Asian Pacific as 88% sample taken from the same region. The authors explained that how the measurable items are loaded on each of its respective constructs.

## VIII. LIMITATIONS AND FUTURE RESEARCH

The research was limited in its findings in a couple of ways. First, the data collected contained only about 4% from America, 5% from Europe, 3% from Australia. The research analysis was majorly based on Asian population and hence could pose a difficulty in understanding the intentions in other countries. Although smart home technologies are more prominent in American, European, Australian regions, the analysis was concentrated on the Asian population. Also, there could be cultural differences between the Asian region and other regions; there might be chances that the preferences might vary. For future research, there could be other factors which could also influence the smart home purchases in the other regions since they are already present there and the awareness level is much better. Furthermore, detailed research must be done on interoperability which proved to be the crucial element in a smart appliances from the findings to understand the intricacies.

Most of the smart home technologies were first adapted in the developed markets. There is diffusion of products and services happening in fast developing markets like Asia. The insight of consumer behavior is an attractive proposition as previously such studies have not focused in the Asian region. Hence we have conducted the study by focusing Asian Pacific region. The future scope of the research

can be extended to compare purchase decision factors from other continents such as America, Europe, and Australia.

## IX. CONCLUSION

The objective of this study is to understand the factors influencing the purchase of smart appliances in smart homes. By collecting responses from about 302 respondents who comprise of both existing and potential users of smart appliances, a research model was developed. The results indicate that the influencing factors "technology, privacy & control, awareness, social factors, interoperability" strongly influence the purchase intention. The research provides a new perspective of the influencing factors which the 'smart appliance developers' can make use of these factors when planning their strategy thereby promoting their smart appliances.

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Insert Annexure 1

**Annexure 1**

| Metric | TE1. Smart appliances have the ability to adapt to each user style preferences | TE2. It is necessary to connect all smart appliances to a single application in smartphone/ tablets for better control | TE3. Reduction in energy consumption by smart appliances automatically will be a vital factor for considering smart appliance purchase | TE4. Smart Grid* enhances the accuracy of energy saving in homes. Smart Grid an electricity supply network that uses digital communications technology to detect and react to local changes in usage | PC1. It is a requisite for smart appliances to alert users in case of emergency | PC2. All smart appliances have the option of surveillance as this will help to monitor each part of the house tremendously | PC3. Voice control to pass information from one smart appliance to another is a significant advantage | PC4. In case of fire or burglary, the smart appliance contacts the concerned gov. department immediately without waiting for the acknowledgment of the user |
|---|---|---|---|---|---|---|---|---|
| Mean | 4.02317/8808 | 4.182119205 | 4.261589404 | 4.112582781 | 4.440397351 | 3.748344371 | 3.96688741 | 4.069536424 |
| Standard Error | 0.05417974 | 0.056383205 | 0.050118607 | 0.052039459 | 0.05767979 | 0.05978206 | 0.054868866 | 0.064274873 |
| Median | 4 | 4 | 4 | 4 | 5 | 4 | 4 | 4 |
| Mode | 4 | 5 | 5 | 4 | 5 | 4 | 4 | 5 |
| Standard Deviation | 0.941543492 | 0.979835642 | 0.870968524 | 0.904349375 | 1.002367881 | 1.038901433 | 0.953519228 | 1.116978207 |
| Sample Variance | 0.886504147 | 0.960077886 | 0.75858617 | 0.817847792 | 1.00474137 | 1.079316187 | 0.909198918 | 1.247640316 |
| Kurtosis | 1.662463603 | 2.181697233 | 2.072524726 | 1.328604137 | 3.583784735 | -0.6149422 | 0.365829438 | 0.772635309 |
| Skewness | -1.296436118 | -1.524142776 | -1.415278762 | -1.255136954 | -2.066708433 | -0.572415046 | -0.928952305 | -1.246587209 |
| Range | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Minimum | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Maximum | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Sum | 1215 | 1263 | 1287 | 1242 | 1341 | 1132 | 1198 | 1229 |
| Count | 302 | 302 | 302 | 302 | 302 | 302 | 302 | 302 |
| Largest(2) | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Smallest(2) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Confidence Level (95.0%) | 0.106619038 | 0.110955187 | 0.09862723 | 0.10240723 | 0.113506705 | 0.117643712 | 0.107975153 | 0.126485015 |

| Metric | LA1. There are enough advertisements today to demonstrate the benefits of smart appliances | LA2. Live Demonstrati-on of Smart Appliances are currently available in your locality | LA3. Recommendat ions from colleagues is a decisive factor to buy a smart appliance | LA4. If the quality of a smart appliance is very good in terms of features and energy saving management, purchase occurs even if price is on a higher side | SB1. Smart appliance is culturally acceptable in terms of its features | SB2. An international product can be adapted to the local market | SB3. Smart appliances have a facility in local language | SB4. Personalizatio n option is provided in smart appliances to set user preferences |
|---|---|---|---|---|---|---|---|---|
| Mean | 3.152317881 | 2.877483444 | 3.30794702 | 3.430463576 | 3.735099338 | 3.973509934 | 3.51986755 | 3.907284768 |
| Standard Error | 0.069334711 | 0.074937132 | 0.066695706 | 0.065167234 | 0.057906381 | 0.054880815 | 0.066449478 | 0.057772866 |
| Median | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 |
| Mode | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 |
| Standard Deviation | 1.20490881 | 1.302268513 | 1.159047792 | 1.132485778 | 1.006305613 | 0.953726873 | 1.154768813 | 1.00398537 |
| Sample Variance | 1.451805241 | 1.69590328 | 1.343391785 | 1.282524037 | 1.012650987 | 0.909594948 | 1.333491012 | 1.007986623 |
| Kurtosis | -0.98929608 | -1.073729319 | -1.109584177 | -0.96445594 | -0.287945634 | 0.291854845 | -0.767477658 | -0.216099355 |
| Skewness | -0.032029336 | 0.047212425 | -0.325159689 | -0.406680551 | -0.788171364 | -0.941580619 | -0.498283114 | -0.843926987 |
| Range | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Minimum | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Maximum | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Sum | 952 | 869 | 999 | 1036 | 1128 | 1200 | 1063 | 1180 |
| Count | 302 | 302 | 302 | 302 | 302 | 302 | 302 | 302 |
| Largest(2) | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Smallest(2) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| Confidence Level (95.0%) | 0.13644215 | 0.147467024 | 0.131248914 | 0.12824107 | 0.113952608 | 0.107998667 | 0.130764369 | 0.113689867 |

| Metric | IO1. It is necessary to standardize User Interface of various appliances in a single format for better understanding and operability | IO2. By making all smart appliances interconnected over internet, security is compromised | IO3. It is necessary for manufacturers of smart appliances to standardize the appliance features | IO4. Internet connection is required to connect at any time | UA1. Usability of appliances ensures purchase of smart appliances | EA1. Usage of smart appliances ensures ease of control | CS1. Smart appliances usage helps in saving cost | SS1. Quality of smart appliances ensures stakeholder satisfaction |
|---|---|---|---|---|---|---|---|---|
| Mean | 3.890728477 | 4.016556291 | 3.764900662 | 4.082781457 | 4.109271523 | 4.086092715 | 3.834437086 | 3.956953642 |
| Standard Error | 0.06727323 | 0.051481027 | 0.060097164 | 0.05105329 | 0.051957146 | 0.051996042 | 0.057993127 | 0.055345129 |
| Median | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Mode | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Standard Deviation | 1.169084089 | 0.894644863 | 1.044377363 | 0.887211585 | 0.902918928 | 0.903594868 | 1.00781309 | 0.961795796 |
| Sample Variance | 1.366757607 | 0.80038943 | 1.090724076 | 0.787144397 | 0.81526259 | 0.816483686 | 1.015687224 | 0.925051154 |
| Kurtosis | -0.283017518 | 1.888629899 | -0.223312042 | 1.827325177 | 0.567725563 | 0.651334088 | -.121492914 | -.140877424 |
| Skewness | -0.916227132 | -1.209518091 | -0.767808691 | -1.197285862 | -1.062398826 | -1.041112304 | -.780151036 | -.838322685 |
| Range | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 3 |
| Minimum | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 2 |
| Maximum | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Sum | 1175 | 1213 | 1137 | 1233 | 1241 | 1234 | 1158 | 1195 |
| Count | 302 | 302 | 302 | 302 | 302 | 302 | 302 | 302 |
| Largest(2) | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Smallest(2) | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 2 |
| Confidence Level (95.0%) | 0.13238541 | 0.101308305 | 0.118263799 | 0.100466571 | 0.102245248 | 0.10232179 | 0.114123313 | 0.10891238 |